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Lone Motherhood, Childhood Resources, and the Dynamics of Skill Formation

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Abstract

Children who experience lone motherhood differ from children who remain with both biological parents before family transitions occur, complicating observed family-structure gaps. Using the Children of the NLSY79, we estimate a dynamic model of family arrangements, financial resources, parental investment, and child skills with persistent family heterogeneity. A transition into lone motherhood at age 7 generates a persistent resource decline and gradually widening skill differences, reducing schooling and adult wages. A Shapley decomposition attributes about 94 percent of the adult effects to the resource-to-skill pathway. Complementary counterfactuals show that timing and persistence shape the developmental consequences of family change.

JEL classification

C33, C38, I24, J12, J13, J24

Keywords

family structure, financial resources, child development, cash transfers, skill formation, latent heterogeneity

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1 Introduction

Children who spend part of childhood apart from a biological parent have substantially lower educational attainment and adult earnings than children who live continuously with both biological parents. Interpreting these gaps is difficult because families following different relationship paths may already differ in skills, family background, preferences, and other persistent characteristics that also shape children's development (McLanahan and Sandefur, 1994; Carlson and Corcoran, 2001; Amato, 2005; McLanahan and Percheski, 2008; McLanahan et al., 2013). At the same time, a family transition can itself change the economic resources, parental time, relationships, stability, and neighborhoods experienced by a child. Recent administrative evidence reinforces this point: divorce changes income, neighborhood circumstances, and proximity to parents, and earlier exposure is associated with larger differences in adult outcomes (Johnston et al., 2025).[1] Observed family-structure gaps therefore combine persistent selection into family histories with the consequences of family change.

Family structure is a dynamic process in which transitions can change several dimensions of a child's environment at once. Understanding their developmental consequences therefore requires asking not only whether outcomes differ across family states, but what changes when a transition occurs, when those changes occur, how long they persist, and how they propagate through childhood.

Changes in financial resources are one potentially important mechanism through which family transitions affect child development. Lone-mother families generally have lower incomes, are more likely to participate in public programs, and have less access to employer-linked benefits. Yet income at a particular age is an incomplete measure of the economic environment available to a child over childhood. Eshaghnia et al. (2025) show that estimates of intergenerational influence depend importantly on whether parental resources are represented by snapshot or longer-term measures and on the ages at which resources are measured, while evidence on childhood food-stamp exposure shows that public support can have long-run consequences not summarized fully by contemporaneous cash income (Bailey et al., 2024). More broadly, quasi-experimental and randomized evidence indicates that changes in resources can affect child outcomes, but that effects differ across interventions and ages of exposure (Akee et al., 2010; Duncan et al., 2011; Dahl and Lochner, 2012; Barr et al., 2022; Noble et al., 2025; Krause et al., 2026). Dynamic skill-formation models provide a natural framework for such timing differences because resources and investments can affect current skills, which become inputs into later development (Cunha and Heckman, 2008; Cunha et al.,

[1] Other approaches to the causal effects of family structure include comparisons across blended families and variation generated by unilateral-divorce laws (Ginther and Pollak, 2004; Gruber, 2004).

2010; Agostinelli and Wiswall, 2025; Del Bono et al., 2022).

Taken together, this evidence raises a set of questions that are difficult to answer separately. How much of the association between family histories and child outcomes reflects persistent differences across families, and what happens following a subsequent family transition? What resource path does such a transition generate, and how does that path propagate through skill formation? Through which channels do the developmental effects operate? And how do the consequences depend on when family circumstances change and how long the resulting resource differences persist? Answering these questions jointly requires a framework in which family structure, resources, investment, and skills evolve together over childhood. Recent work jointly modeling changing family relationships and child development and evidence on the joint evolution of family structure and parental income underscore both the selection problem and the importance of timing (Chan and Liu, 2025; Chang et al., 2026).

We address these questions using the Children of the NLSY79 and a dynamic model linking family structure, a multidimensional financial resource state, parental investment, cognitive and noncognitive skills, and adult outcomes. The family-state process distinguishes residence with the mother and biological father, residence with the mother and a social father or partner, and residence with a lone mother. Financial resources are latent and measured jointly by family income, SNAP receipt, and private child health insurance; cognitive skill, noncognitive skill, and parental investment are also latent and measured using multiple indicators. The model follows family states and these latent states at ages 5, 7, 9, 11, and 13 and links age-13 skills to completed schooling and adult wages.

Persistent selection is represented by two permanent latent family types. Type can shift age-5 resources, skills, investment, and the propensities to enter the social-father and lone-mother states, while the resource, investment, and skill response technologies remain common across types in the preferred specification. This structure does not eliminate all possible selection into family change; rather, it allows for persistent selection on time-invariant unobserved family characteristics. It also separates two counterfactual objects. The first changes family state and therefore allows resources, investment, and subsequent family states to respond endogenously. The second changes financial resources while holding the family path fixed. Comparing them shows how the consequences of family change are related to the size, persistence, and timing of the resource path it generates.

The estimated model produces four main findings. First, our preferred family counterfactual starts both worlds with biological-parent residence at age 5 and then compares remaining in that state at age 7 with a transition into lone motherhood. Because both counterfactual worlds share biological-parent residence and the same modeled developmental history at age 5, the experiment isolates a subsequent divergence in family state rather than an initial

difference in family environment. The transition immediately lowers the resource state by 0.147 standard deviations. The resource gap widens to 0.204 standard deviations at age 9 and about 0.215 by age 13, while initially small skill differences accumulate. By age 13, cognitive and noncognitive skills are lower by 0.033 and 0.041 standard deviations, respectively. These differences imply 0.057 fewer years of completed schooling and 0.011 lower adult log wages.

Second, an exact three-channel Shapley decomposition attributes most of these developmental consequences to the resource-to-skill pathway that operates outside the parental-investment measures observed in the CNLSY. At age 13, this component accounts for 0.031 of the 0.033-standard-deviation cognitive decline and 0.039 of the 0.041-standard-deviation noncognitive decline. It accounts for roughly 94 percent of the schooling and wage effects as well. Bootstrap inference shows that this dominant resource-to-skill component is precisely estimated, whereas the much smaller investment-mediated components are generally imprecise. Because the resource state is measured jointly by income, SNAP receipt, and private insurance, we interpret this as a broader resource-environment pathway rather than a pure income effect.

Third, timing matters sharply. An age-5 family-state assignment to lone-mother rather than biological-parent residence—which changes the initial resource and developmental environment as well as subsequent histories—produces much larger effects: age-13 cognitive and noncognitive skills fall by 0.196 and 0.250 standard deviations, completed schooling by 0.343 years, and adult log wages by 0.068. The corresponding effects decline substantially when the family paths begin to diverge at later ages. In an aligned one-type specification, the effects of this age-5 assignment are about one-quarter larger. This comparison shows that persistent selection matters for the early family-state contrast; it should not be interpreted as implying an equivalent selection correction for the preferred age-7 transition.

Fourth, resource counterfactuals isolate the consequences of changing the economic environment while holding family structure fixed and show the importance of scale, persistence, and timing. A one-time \$10,000 resource increment at age 5 raises age-13 cognitive and noncognitive skills by 0.087 and 0.111 standard deviations, completed schooling by 0.152 years, and adult log wages by 0.030. Repeating the same increment at all five modeled ages produces larger effects, while delaying an otherwise identical one-time increment produces smaller developmental consequences. Unlike the family-state counterfactual, the response to an externally imposed resource increment is virtually unchanged between the one- and two-type specifications.

The paper's central contribution is to distinguish within a common developmental framework three economically different objects: persistent differences across families, the developmental consequences of a subsequent family transition, and the consequences of changing

financial resources while holding family structure fixed. The model connects dynamic family relationships and selection (Chan and Liu, 2025; Chang et al., 2026) with dynamic skill formation (Cunha and Heckman, 2008; Cunha et al., 2010; Agostinelli and Wiswall, 2025; Del Bono et al., 2022) by allowing family transitions to alter a persistent, multidimensional resource state and parental investment, which then propagate through child development. This common framework also connects the family-transition evidence to income and transfer interventions (Akee et al., 2010; Dahl and Lochner, 2012; Barr et al., 2022; Noble et al., 2025; Krause et al., 2026) and makes it possible to compare family transitions with resource interventions that vary in magnitude, duration, and timing. Taken together, the results show how persistent selection, changes in family circumstances, and the dynamic accumulation of childhood resources and skills interact in determining when, why, and through what mechanisms family structure matters for children's long-run outcomes.

The remainder of the paper proceeds as follows. Section 2 describes the data, measurement system, and descriptive dynamics. Section 3 presents the model, Section 4 discusses identification, and Section 5 describes estimation. Section 6 presents the structural evidence, Section 7 reports the counterfactual exercises, and Section 8 concludes.

2 Data, Measurement, and Descriptive Dynamics

2.1 Data source and estimation sample

We use the National Longitudinal Survey of Youth 1979 (NLSY79) and its linked Child and Young Adult surveys. The original NLSY79 follows a nationally representative cohort of men and women who were ages 14–22 in 1979. Beginning in 1986, the Child survey collected repeated information about the children born to female NLSY79 respondents, including assessments of achievement and behavior and detailed reports about the child's home and family environment. The Young Adult survey subsequently followed these children as they entered adulthood. Linking the three surveys allows us to observe maternal characteristics measured before or early in the child's life, the child's family environment and development across childhood, and educational and labor-market outcomes in adulthood.

We organize the childhood data around ages 5, 7, 9, 11, and 13. Survey observations are assigned to the corresponding developmental period using age windows centered on these ages. The biennial structure provides repeated observations during a period in which family arrangements, economic resources, parental inputs, and skills may all change. It also permits us to distinguish transitory measurement variation from persistent differences and to examine how conditions at one age predict development at later ages.

The estimation sample contains 2,975 children. We retain the oldest child who satisfies the estimation requirements for each NLSY79 mother. Using one child per mother gives a direct mapping between the model's permanent family component and one developmental history and avoids treating the unobserved family components of siblings as independent. The restriction also prevents mothers with more observed children from receiving greater weight in estimation.

Table 2 reports measurement availability at each modeled age. Because the longitudinal surveys do not observe every child or every measure at every age, the resulting childhood panel is unbalanced. The table reports availability separately for each indicator as well as the number of children with at least one observed measure in each domain. Estimation does not require complete information on every indicator or a balanced history: each child contributes through the family arrangements and measurements observed at each age. Nearly every child has some usable information at each modeled age, although availability is lower for individual indicators. Completed schooling at age 23 is observed for 1,217 children, and wages at age 29 are observed for 742 children.

2.2 Family arrangements and background characteristics

At each modeled age, we classify the child's family arrangement according to the adults residing with the child. State B denotes residence with the mother and the child's biological father. State P denotes residence with the mother and a social father or partner. State L denotes residence with a lone mother, without either the biological father or a social father or partner in the household. The distinction between B and P allows biological-parent and social-parent households to have different resource and investment implications rather than combining them into a single two-parent category.

Family arrangement is observed repeatedly rather than defined by a single childhood observation. A child can therefore occupy different states at different ages. These histories record both the timing and duration of exposure to each arrangement. They also distinguish transitions from biological-parent residence into lone motherhood from subsequent entry into a social-parent household.

The data also contain characteristics that precede or are predetermined with respect to the childhood family histories. These include the mother's education, cognitive and noncognitive skills, age at the child's birth, and frequency of religious attendance, together with the education of the maternal grandparents and whether the mother lived with a single mother at age 14. These variables describe dimensions of maternal and family background that may be associated with both later family arrangements and children's initial conditions. They are

used as conditioning variables in the family, resource, investment, and initial-skill equations rather than interpreted as independently assigned inputs. When a background characteristic is unavailable, we retain the observation and include the corresponding missing-value indicator.

Table 3 summarizes the distribution of the three family arrangements at each modeled age and transitions between adjacent ages. Family arrangements are persistent but not absorbing: some children move from biological-parent residence into lone motherhood, some enter social-parent households, and others experience further transitions. The main table reports the transitions needed to display the principal patterns compactly.

2.3 Child skills and parental investment

Cognitive skill is measured using the mathematics, word recognition, and reading comprehension assessments from the Peabody Individual Achievement Test. These repeated assessments capture related but distinct dimensions of academic achievement. Using them jointly reduces reliance on any single test and permits the model to separate a common cognitive component from test-specific measurement error.

Noncognitive skill is measured with three components of the Behavior Problems Index. The original items record behavioral difficulties reported by the mother. We orient the measures so that higher values correspond to stronger noncognitive skills and hence have the same qualitative interpretation as higher cognitive scores. These reports provide repeated indicators of the child's underlying behavioral and socioemotional development; they are not treated as error-free observations of that latent state.[2]

Parental investment is measured using age-appropriate indicators of activities and features of the home environment. The measures include reading with or to the child, museum visits, time spent with friends or family, praise, and an indicator of the quality of the home environment. The particular indicators available and most informative vary with the child's age. The empirical measurement system therefore uses age-specific combinations of the observed measures while maintaining a common interpretation of the latent investment state: higher values represent a more intensive set of measured parental and home inputs. The age-specific combinations reflect the measurement availability in the CNLSY.

As an external check on the interpretation of these indicators, we use the Bureau of Labor

[2]The Behavior Problems Index is reported by the mother. Parent reports of children's behavioral and emotional development may contain observer-specific reporting error, and assessments can differ systematically across parents, teachers, children, and clinical observers (Johnston et al., 2014). More specifically, Del Bono et al. (2026) show that parental characteristics can contaminate parent-reported noncognitive measures and thereby alter estimates of skill dynamics. Using multiple BPI components allows our measurement system to separate a common latent component from indicator-specific error, but it cannot remove reporting variation shared across the mother-reported measures. We therefore interpret the resulting factor as noncognitive skill as measured through maternal reports.

Statistics American Time Use Survey (ATUS) (U.S. Bureau of Labor Statistics, 2026) to examine whether activities resembling the CNLSY measures are associated with a broader set of developmental time inputs. The ATUS records a detailed diary for a single day and identifies the household members present during each activity. Among mothers with an own child ages 5–13, participation in reading, museum attendance, and shared social or leisure activities has a survey-weighted correlation of 0.40 with participation in a separate measure comprising play, arts and crafts, sports, conversations, educational assistance, attendance at children's events, and organizational activities undertaken for children. The correlation ranges from 0.31 to 0.43 across child-age groups and is 0.38 when the sample is restricted to mothers with exactly one own child. This evidence does not establish that the CNLSY indicators measure parental investment without error. It supports their interpretation as observable markers of a broader investment environment. Appendix Table A.3 provides the definitions and results.

Before estimation, we orient all skill and investment measures so that higher values represent stronger skills or greater parental investment. We then standardize or rescale the observed indicators using transformations appropriate to each measurement domain. Table 4 reports means and standard deviations for the transformed indicators used in estimation. The pooled standardization of the cognitive measures preserves the pronounced age profile in achievement, whereas the within-age transformations of the noncognitive and investment indicators remove their general age profiles. Standardizing an observed indicator is distinct from normalizing the scale of its latent factor; the loading normalizations that set the latent-factor scales are introduced in Section 4.

The use of multiple indicators is important throughout the analysis. Test scores, maternal reports of behavior, and reports of activities in the home are all noisy measures. Treating any one of them as the state itself would confound changes in the underlying construct with measure-specific variation. The model introduced in Section 3 instead relates each group of indicators to a latent state and uses their joint evolution across ages to learn about skill and investment dynamics.

2.4 Financial-resource measures

We measure the child's financial-resource environment using three observed outcomes: total family income, household receipt of benefits from the Supplemental Nutrition Assistance Program (SNAP), and whether the child is covered by private health insurance. Income measures the family's current cash resources. SNAP receipt provides additional information about economic need and participation in the public safety net. Private insurance captures

access to a benefit commonly connected to employment and to more stable or better-compensated jobs. We expect SNAP participation to be associated with fewer financial resources and private coverage to be associated with greater resources, although program eligibility, take-up, and employment arrangements prevent either measure from being a deterministic transformation of income.

The NLSY79 total net family income measure combines earnings with reported public and private transfers and other income sources. For a lone mother, it therefore includes child-support and alimony payments received from a nonresident parent, but not that parent's earnings or unpaid support obligations. The treatment of a resident father or partner depends on marital status rather than on whether he is the child's biological father: the earnings of a husband are included, whereas those of an unmarried cohabiting partner are excluded from the constructed measure. Income may consequently understate the resources available in some cohabiting households in both the biological-father and social-father-or-partner states. This feature provides an additional reason to combine income with SNAP receipt and private insurance rather than treating reported family income as a complete measure of the child's financial environment.[3]

These additional measures address an important limitation of using income observed at one survey date as the complete description of the resources available to a child. Reported income contains measurement error, can fluctuate temporarily, and does not by itself record access to means-tested support or employment-linked benefits. More generally, Eshaghnia et al. (2025) show that conclusions about the role of parental resources can depend importantly on the ages at which income is measured and on whether resources are represented by contemporaneous income or longer-term measures. Evidence that childhood access to food stamps has long-run effects on human capital and economic self-sufficiency further illustrates why safety-net participation is informative about a dimension of the childhood resource environment not exhausted by current income (Bailey et al., 2024). The three observed measures therefore provide complementary evidence about a persistent resource state. At this stage, however, we describe only what is observed. The formal definition of the resource factor, its measurement equations, and the assumptions that distinguish the factor from measurement error are presented in Sections 3 and 4.

Table 5 documents the three resource measures. Panel A reports family income in constant dollars together with SNAP participation and private-insurance coverage at each modeled age. Panel B reports the pairwise correlations among log family income, SNAP receipt, and

[3]The NLSY79 documentation defines total net family income using income received by the respondent and household members related by blood, marriage, or adoption. It documents child support and alimony among the income sources collected and notes that an unmarried partner's earnings are excluded from the constructed measure.

private insurance. The signs indicate whether the measures move together as expected, while their magnitudes show the extent to which SNAP and insurance provide information beyond contemporaneous income.

Figure 1 traces the same three measures around the first observed transition from biological-parent residence to lone-mother residence. Event time zero denotes the first modeled age at which the child resides with a lone mother. Between the last observed biological-parent period and the first lone-mother period, mean log family income falls by 0.58 log points, SNAP receipt rises from 22.5 to 29.4 percent, and private-insurance coverage falls from 73.1 to 64.0 percent. SNAP participation returns almost immediately to its pre-transition rate, consistent with a relatively short-lived safety-net response among the families observed after the transition. Income and private coverage also recover in part, but remain below their pre-transition levels over the observable post-transition periods. The contrast illustrates why no single observed measure fully describes the evolution of the broader resource environment.

The figure is descriptive: it records how observed resources evolve around the transition but does not separate the consequences of family change from selection into different family histories. Moreover, transition ages differ, so the children contributing at a given event time are not identical throughout the full event window. An appendix version removes age-specific means and rescales each measure by its age-specific standard deviation. The sharp change at event time zero remains: age-standardized log income falls by about 0.70 standard deviations, while SNAP and private coverage move by about 0.22 standard deviations in the directions associated with fewer resources.

As with the skill and investment indicators, availability of the resource measures varies across ages and children. We retain an observation indicator for each measure and use an outcome only when it is observed. Missing resource measurements are handled within the likelihood as described in Section 5.

2.5 Adult outcomes

The childhood histories are linked to two outcomes that summarize later human capital and labor-market performance. Completed schooling is measured at age 23, by which time most respondents have completed their initial schooling, while preserving broad sample coverage. Labor-market performance is measured by log wages at age 29. These outcomes allow the model to translate differences in childhood skill trajectories into units that are economically interpretable. Because schooling and wages are observed after the childhood state process, they do not enter the childhood transitions; they are modeled as outcomes of the skills accumulated by the end of the childhood period together with observed controls.

2.6 Descriptive family and resource dynamics

Several features of the data motivate the model that follows. Table 3 shows that family arrangements are persistent but not absorbing. Across adjacent modeled ages, 91.8 percent of observations beginning in state B remain there, compared with 75.5 percent for state P and 86.3 percent for state L. At the same time, 6.3 percent of adjacent observations beginning in B move to L, and movements both into and out of social-parent residence are visible in the data. A model based only on family status at one age would discard this timing and duration information.

Family arrangements are also systematically associated with economic resources. As shown in Appendix Table A.1, at age 5 mean log income is 10.02 among children living with lone mothers and 10.97 among those living with their mother and biological father. The corresponding SNAP participation rates are 42.8 and 8.8 percent, while private-insurance coverage rates are 50.4 and 84.3 percent. Children living with a social father or partner form a distinct group rather than mapping uniformly into either of the other arrangements. Figure 1 complements these cross-sectional comparisons by showing how the three observed resource measures evolve around entry into lone motherhood. At the same time, the resource distributions overlap across family states. Family arrangement is therefore informative about resources but is not itself a resource measure.

The observed skill and investment indicators also differ across family arrangements, as do maternal education, maternal skills, and family-of-origin characteristics (Appendix Table A.2). These differences make a direct comparison of children across contemporaneous family states difficult to interpret. They may reflect consequences of the current or earlier family environment, persistent selection into relationship paths, or both. Repeated family histories, repeated resource and developmental measures, and predetermined background characteristics provide the empirical variation used below to separate these components.

Taken together, the descriptive evidence establishes three features that the model must accommodate. Family arrangements are persistent but transitions occur over childhood. Financial resources and developmental inputs differ across arrangements and change around family transitions. Skills and parental investment are themselves persistent, so differences arising at one age can carry into later development. These patterns motivate a model in which family states evolve over childhood, financial resources respond to family states and persist, and skills and investment accumulate dynamically. Because families following different histories also differ before transitions occur, the model additionally allows for persistent unobserved family heterogeneity. None of the descriptive gaps is interpreted as causal.

3 Dynamic Model

3.1 Overview, timing, and mechanisms

The model is designed to distinguish persistent selection into family environments from the consequences of a change in family arrangement. It jointly describes family structure, financial resources, parental investment, cognitive and noncognitive skills, and adult outcomes. Its developmental component builds on the dynamic skill-formation framework in which latent skills and parental investments evolve jointly and are inferred from repeated noisy measurements (Cunha et al., 2010; Agostinelli and Wiswall, 2025; Cunha et al., 2021). Families may differ permanently in unobserved characteristics that predict both the family arrangements children experience and their initial developmental conditions. Conditional on this heterogeneity, changes in family arrangement can alter resources and parental investment, which in turn affect the evolution of skills.

Time is discrete. The five modeled periods correspond to child ages $t \in \{5, 7, 9, 11, 13\}$. Let $F_{it} \in \{B, P, L\}$ denote the family arrangement of child i at age t: residence with the mother and biological father (B), residence with the mother and a social father or partner (P), and residence with a lone mother (L). Let

$$\Theta_{it} = (C_{it}, I_{it}, N_{it})' \tag{1}$$

collect latent cognitive skill (C_{it}), parental investment (I_{it}), and noncognitive skill (N_{it}), and let R_{it} denote the latent financial resource state. The complete vector of continuous childhood states is therefore $U_{it} = (\Theta'_{it}, R_{it})'$.

The within-period ordering is recursive. Permanent type and predetermined maternal and family-background characteristics are fixed before the childhood process begins. At each age, the family arrangement is realized first. Current family arrangement and lagged resources then determine current resources. Family arrangement can also affect parental investment directly. Conditional on these states and predetermined maternal characteristics, current resources enter parental investment and both skill equations, while lagged cognitive skill, investment, and noncognitive skill determine the remaining dynamic part of the current developmental states. The current states become inputs into the next modeled age. In abbreviated form, the within-period ordering is

$$F_{it} \longrightarrow R_{it} \longrightarrow (C_{it}, I_{it}, N_{it}), \tag{2}$$

with an additional direct link from F_{it} to I_{it}, direct inputs from maternal cognitive and

noncognitive skills into the developmental equations, and dynamic links from $\Theta_{i,t-1}$ to Θ_{it}. Current investment does not enter current skills contemporaneously; instead, I_{it} affects skills at subsequent modeled ages through the transition matrix.

This structure generates three channels through which a family transition can affect skills. First, family arrangement can change resources, which enter cognitive and noncognitive skills directly. Second, the resource change can alter measured parental investment and thereby affect later skills. Third, family arrangement can change investment even after current resources are held fixed. Family arrangement does not otherwise enter the cognitive or noncognitive equations. This exclusion is substantive: within the model, the developmental consequences of family change operate through the modeled resource and investment paths and their subsequent propagation through skill formation. It is this restriction that gives the later mechanism decomposition its interpretation.

Dynamics are central to the interpretation. A transition early in childhood can alter the resource and investment paths over several later ages, and the resulting skill changes can persist through self- and cross-productivity. A later transition leaves less time for these effects to accumulate. The model therefore distinguishes not only which family arrangement a child experiences, but also when transitions occur and how long their consequences persist.

3.2 Permanent heterogeneity and initial conditions

We represent persistent unobserved differences among families using a finite mixture. Let

$$T_i \in \{0, 1\}, \qquad \Pr(T_i = 1) = \pi,$$

where T_i is fixed over the entire childhood history. The two-point mixture provides a parsimonious discrete approximation to persistent characteristics that are not fully captured by the observed background variables.

Permanent type shifts the age-5 means of cognitive skill, parental investment, noncognitive skill, and resources. It also shifts the propensities to reside in the social-parent and lone-mother states. The resulting correlation allows families with different underlying relationship propensities to begin childhood with different resource and developmental conditions. Without this component, persistent differences associated with family histories could be attributed to the response to a contemporaneous family transition.

For a generic initial state $j \in \{C, I, N, R\}$, the type shift is written in mean-preserving form,

$$\delta_j(0) = -\pi d_j, \qquad \delta_j(1) = (1 - \pi) d_j,$$

so that $(1-\pi)\delta_j(0) + \pi\delta_j(1) = 0$. The distance d_j measures the difference between the two support points without changing the population-average intercept. The family-propensity shifts are parameterized analogously.

At age 5, the resource state is generated first, conditional on the initial family arrangement:

$$R_{i5} = a_5^R + X_{iR}' b_5^R + \gamma_{P5}^R \mathbf{1}\{F_{i5} = P\} + \gamma_{L5}^R \mathbf{1}\{F_{i5} = L\} + \delta_R(T_i) + \varepsilon_{i5}^R. \tag{3}$$

The vector X_{iR} contains the predetermined maternal and family-of-origin characteristics used in the initial resource equation, including maternal education and skills, grandparental education, and the mother's adolescent family arrangement. Missing-education indicators allow observations with unavailable background measures to remain in the sample.

Conditional on R_{i5}, the initial developmental states satisfy

$$C_{i5} = a_5^C + X_{iC}' b_5^C + \delta_C(T_i) + \beta_{R5}^C R_{i5} + \varepsilon_{i5}^C, \tag{4}$$

$$I_{i5} = a_5^I + X_{iI}' b_5^I + \delta_I(T_i) + \gamma_{P5}^I \mathbf{1}\{F_{i5} = P\} + \gamma_{L5}^I \mathbf{1}\{F_{i5} = L\} + \beta_{R5}^I R_{i5} + \varepsilon_{i5}^I, \tag{5}$$

$$N_{i5} = a_5^N + X_{iN}' b_5^N + \delta_N(T_i) + \beta_{R5}^N R_{i5} + \varepsilon_{i5}^N. \tag{6}$$

The covariate vectors differ across equations. Maternal cognitive and noncognitive skills enter all three initial developmental states directly; maternal education enters initial investment and resources. The age-5 equations also include Black and Hispanic indicators as observed controls. Family arrangement enters initial investment directly but has no additional direct coefficient in either initial skill equation; its contemporaneous effect on C_{i5} and N_{i5} therefore operates through R_{i5}. Type shifts the levels of all four initial latent states, while the response coefficients are common across types in the preferred specification.

Keeping the response technology common is deliberate. Permanent type is introduced to capture persistent selection into family arrangements, resources, and initial conditions. It does not mechanically create different resource or skill technologies. Consequently, counterfactual family arrangements can be compared for the same child and type, while an externally imposed resource change is evaluated using the same technology for both types.

3.3 Family-arrangement dynamics

Family arrangement follows a three-state multinomial process. Biological-father residence is the reference alternative. Let $s \in \{P, L\}$ index the two nonreference states and let H_{it}^F collect the observed history available when the age-t arrangement is realized. At age 5, the two indices are

$$V_{i5}^s = a_5^s + Z_i' \alpha_5^s + \delta_F^s(T_i), \qquad s \in \{P, L\}, \tag{7}$$

where Z_i contains maternal age at birth, maternal religious attendance, whether the mother herself lived with a lone mother in adolescence, and Black and Hispanic indicators. For later ages,

$$V_{it}^s = a_t^s + Z_i'\alpha_t^s + \rho_P^s \mathbf{1}\{F_{i,t-1} = P\} + \rho_L^s \mathbf{1}\{F_{i,t-1} = L\} + \delta_F^s(T_i), \qquad s \in \{P, L\}. \tag{8}$$

The lagged-state coefficients allow persistence and movement among all three arrangements. For example, the probability of entering a social-parent household can differ according to whether the child previously lived with the biological father or a lone mother.

The multinomial-logit probabilities are

$$\begin{aligned} \Pr(F_{it} = B \mid H_{it}^F, T_i) &= \frac{1}{1 + \exp(V_{it}^P) + \exp(V_{it}^L)}, \\ \Pr(F_{it} = s \mid H_{it}^F, T_i) &= \frac{\exp(V_{it}^s)}{1 + \exp(V_{it}^P) + \exp(V_{it}^L)}, \qquad s \in \{P, L\}. \end{aligned} \tag{9}$$

The same permanent type influences the family process and the age-5 latent states. This is the source of correlated persistent selection in the model.

3.4 Financial-resource dynamics

The resource state summarizes the common financial component measured by family income, SNAP receipt, and private child health insurance. It is distinct from any individual indicator. In particular, R_{it} is not observed income with SNAP and insurance included as separate regressors. The three observed outcomes are measurements of a latent state whose evolution is specified here and whose measurement equations are presented below.

The age-5 resource equation is given in (3). At later ages, resources follow

$$R_{it} = a_t^R + \rho_R R_{i,t-1} + \gamma_{Pt}^R \mathbf{1}\{F_{it} = P\} + \gamma_{Lt}^R \mathbf{1}\{F_{it} = L\} + \varepsilon_{it}^R, \qquad t \in \{7, 9, 11, 13\}. \tag{10}$$

The persistence parameter ρ_R carries earlier resource differences forward. The age-specific family coefficients measure how residence with a social father or a lone mother shifts current resources relative to biological-parent residence, conditional on lagged resources. Because the current family arrangement is realized before current resources, a transition can change R_{it} immediately, while persistence can extend the difference beyond the period in which it first appears.

Permanent type enters resources through the initial condition rather than through type-specific transition or response parameters. Conditional on age-5 resources and the subsequent

family history, both types follow the same resource process. This restriction separates persistent differences in the resources with which families enter the modeled period from the effect of later family arrangements on the resource path.

3.5 Skill formation and parental investment

The transition system allows for self-productivity and cross-productivity among cognitive skill, noncognitive skill, and parental investment. Related empirical models use this structure to study how investments combine with existing child capabilities and how the productivity and timing of investments vary across developmental stages (Cunha and Heckman, 2008; Cunha et al., 2010; Attanasio et al., 2020a,b; Agostinelli and Wiswall, 2025). Our extension adds the current resource state and family arrangement to this dynamic system.

For ages after 5, the portion of each developmental state determined before the contemporaneous resource effect is

$$\widetilde{C}_{it} = a_t^C + g_t^{CC} C_{i,t-1} + g_t^{CI} I_{i,t-1} + g_t^{CN} N_{i,t-1} + \eta_{Ct}^{CM} M_i^C + \eta_{Ct}^{NM} M_i^N + \varepsilon_{it}^C, \tag{11}$$

$$\begin{aligned}\widetilde{I}_{it} = a_t^I + g_t^{IC} C_{i,t-1} + g_t^{II} I_{i,t-1} + g_t^{IN} N_{i,t-1} + \eta_{It}^{CM} M_i^C + \eta_{It}^{NM} M_i^N \\ + \eta_{It}^{E} M_i^E + \gamma_{Pt}^I \mathbf{1}\{F_{it} = P\} + \gamma_{Lt}^I \mathbf{1}\{F_{it} = L\} + \varepsilon_{it}^I,\end{aligned} \tag{12}$$

$$\widetilde{N}_{it} = a_t^N + g_t^{NC} C_{i,t-1} + g_t^{NI} I_{i,t-1} + g_t^{NN} N_{i,t-1} + \eta_{Nt}^{CM} M_i^C + \eta_{Nt}^{NM} M_i^N + \varepsilon_{it}^N, \tag{13}$$

where M_i^C and M_i^N denote maternal cognitive and noncognitive skills and M_i^E denotes maternal education. The maternal-skill coefficients are age specific. Maternal education enters investment at each modeled age but does not enter the cognitive or noncognitive equations directly. The grandparental and maternal-family-origin variables used in the age-5 resource equation do not enter these developmental equations directly. The diagonal elements of $G_t = (g_t^{jk})$ capture self-productivity: the extent to which a state at one modeled age predicts the same state at the next. The off-diagonal elements capture dynamic cross-productivity. In particular, g_t^{CI} measures the effect of prior parental investment on current cognitive skill, while g_t^{CN} measures the contribution of prior noncognitive skill to current cognition. The corresponding coefficients in the investment and noncognitive equations allow the three developmental states to evolve jointly rather than as independent processes.

After the lagged transition has been formed, current resources enter contemporaneously:

$$C_{it} = \widetilde{C}_{it} + \beta_{Rt}^C R_{it}, \tag{14}$$

$$I_{it} = \widetilde{I}_{it} + \beta_{Rt}^I R_{it}, \tag{15}$$

$$N_{it} = \widetilde{N}_{it} + \beta_{Rt}^N R_{it}. \tag{16}$$

The coefficients β_{Rt}^{C} and β_{Rt}^{N} permit the broader resource state to affect skills beyond the parental-investment indicators observed in the data. The coefficient β_{Rt}^{I} creates an indirect channel: resources can change investment at age t, which then affects skills at subsequent modeled ages through the relevant elements of G_{t+1}.

Family arrangement enters the investment equation directly through the age-specific P and L coefficients. These terms allow measured investment to respond to the presence and identity of a resident parent even after current resources are held fixed. Family arrangement has no additional direct coefficient in the cognitive or noncognitive equations. The model thus attributes family effects on skills to resource changes, changes in measured investment, and the propagation of those states, rather than to an unrestricted residual family coefficient.

The distinction between lagged investment and current resources reflects the timing of the observed data. Investment measured at one modeled age enters skill production at the next modeled age; current resources are allowed to affect current skills and investment. This recursive convention does not impose that investment or noncognitive skill is unproductive for cognition. Their contributions are represented by the lagged cross-productivity coefficients in (11).

3.6 Measurement system

The latent states are connected to observed data through separate measurement systems. Multiple-indicator measurement systems are central to dynamic latent-factor models because they separate common variation in the underlying states from indicator-specific noise (Cunha et al., 2010; Agostinelli and Wiswall, 2025; Del Bono et al., 2022). Let Z_{itm}^{k} denote measurement m of state $k \in \{C, I, N\}$ for child i at age t. The continuous skill and investment measurements satisfy

$$Z_{itm}^{k} = d_{tm}^{k} + \lambda_{tm}^{k}\Theta_{it}^{k} + e_{itm}^{k}, \qquad k \in \{C, I, N\}. \tag{17}$$

The intercepts, loadings, and measurement-error variances may vary across indicators and ages. Conditional on the latent states and observed covariates, the measurement errors are independent across indicators and independent of the state innovations.

Resources have one continuous and two binary measurements. Let Y_{it} denote family income in levels and let $\bar{y}_t$ be the age-specific centering constant. The income equation is

$$\log Y_{it} - \bar{y}_t = R_{it} + e_{it}^{Y}. \tag{18}$$

SNAP receipt and private child health insurance satisfy the probit measurement equations

$$\begin{aligned} \Pr(SNAP_{it} = 1 \mid R_{it}) &= \Phi(\tau_t - \lambda_S R_{it}), \\ \Pr(INS_{it} = 1 \mid R_{it}) &= \Phi(\kappa_t + \lambda_H R_{it}). \end{aligned} \tag{19}$$

The age-specific thresholds allow the prevalence of program participation and insurance coverage to change over childhood. The loadings λ_S and λ_H orient the factor so that greater resources are associated with lower SNAP receipt and higher private coverage. The scale normalizations and identifying assumptions underlying the measurement system are discussed in Section 4.

3.7 Adult outcomes

The childhood process ends at age 13. We link the terminal skill states to completed schooling at age 23 and log wages at age 29. For adult outcome $Q_i \in \{School_i, Wage_i\}$,

$$Q_i = a_Q + \alpha_Q^C C_{i,13} + \alpha_Q^N N_{i,13} + \varepsilon_i^Q. \tag{20}$$

The outcome-specific coefficients translate age-13 cognitive and noncognitive skills into schooling years and log-wage units. There are no additional direct controls for family arrangement, resources, investment, permanent type, race, or maternal and family-background characteristics in these adult equations. Those variables can affect adult outcomes only through the cognitive and noncognitive skills accumulated by age 13. This final mapping allows counterfactual changes in family arrangements and resources during childhood to be followed beyond the last childhood observation.

4 Identification

The parameters are identified jointly from repeated measurements, family histories, observed background characteristics, and the evolution of outcomes across childhood. The central identification problem is to distinguish four objects: latent developmental and resource states, persistent family heterogeneity, dynamic response technologies, and the family and resource counterfactuals. The discussion below focuses on the variation and maintained assumptions that separate these objects rather than restating each model equation.

4.1 Latent states and factor scales

At each modeled age, cognitive skill, noncognitive skill, and parental investment are represented by multiple observed indicators. Within-age covariance identifies their common components and relative loadings, while repeated measurements across ages help distinguish persistent latent states from transitory indicator-specific variation. Conditional on the latent state and observed covariates, measurement errors are assumed to be independent across indicators and independent of the state innovations. One loading for each factor and age is normalized, and the factors are oriented so that higher values represent stronger skills or greater investment. These normalizations set units and signs rather than imposing developmental effects (Agostinelli and Wiswall, 2016; Freyberger, 2026).

The resource state combines centered log family income with SNAP receipt and private child health insurance. Income has unit loading. Conditional variation in SNAP and insurance at a given level of reported income provides additional information about the common resource component; differences in prevalence across ages identify the age-specific binary thresholds. SNAP and insurance are therefore measurements of the resource state, not excluded instruments for resources.

4.2 Persistent family heterogeneity and family transitions

Permanent type is identified from the joint distribution of age-5 measurements and subsequent family histories. Families that follow different sequences of B, P, and L also display different initial resource, skill, and investment measurements. Persistence in these joint differences helps separate a time-invariant family component from transitory state innovations, while predetermined maternal and family-of-origin characteristics explain part of the same variation. Identification relies on the maintained two-point mixture: type is fixed over childhood, shifts the age-5 latent states and propensities for P and L, and is independent of subsequent innovations conditional on observed characteristics. Response technologies are common across types.

Family-transition parameters are identified from movements among B, P, and L over childhood. Differences in destinations among children beginning an interval in each state identify persistence and transition patterns, while variation with predetermined characteristics identifies the observed components of the family process. A structural interpretation requires sequential conditional exogeneity: conditional on observed history and permanent type, the innovation determining current family state is assumed to be unrelated to subsequent resource, investment, and skill innovations. The model therefore allows for persistent selection on time-invariant unobserved family characteristics, but not unrestricted time-varying events

that jointly change family arrangements and child development.

4.3 Dynamic technologies and resource effects

Persistence in the latent resource state is identified from the joint evolution of income, SNAP receipt, and private insurance. Changes in these measurements around movements among B, P, and L provide the principal variation for estimating how family states shift resources. Self- and cross-productivity in skills and investment are identified from cross-age covariances among their repeated measurements, after separating common latent variation from indicator-specific noise.

The effects of resources on cognitive skill, noncognitive skill, and parental investment are identified from variation in the resource state that predicts the corresponding measurements after conditioning on family state, permanent type, observed characteristics, and prior developmental states. Their structural interpretation relies on the recursive timing of the model: current family state precedes current resources, and current resources precede current skills and investment. Conditional on the modeled history, resource innovations are assumed to be unrelated to otherwise unobserved contemporaneous determinants of skills and investment. The distinction between a resource-to-skill channel and a resource-to-investment-to-skill channel is therefore model-based and depends on this timing and the exclusion of an additional direct family-state term from the skill equations.

4.4 Adult outcomes and counterfactual objects

The adult coefficients are identified from the relationship between the filtered age-13 cognitive and noncognitive states and completed schooling and wages. We assume that childhood resources and investment affect these adult outcomes through the cognitive and noncognitive skills accumulated by age 13 rather than through additional direct terms.

These assumptions also clarify the distinction between the two counterfactual objects. The family-state experiment combines the estimated response of resources and investment to family state with the subsequent laws of motion for family arrangements and developmental states. The resource experiment instead intervenes directly on R_t while holding the family path fixed. The former therefore depends importantly on the maintained model of selection into family histories; the latter evaluates an externally imposed resource change through the common estimated developmental technology. A sequential instrumental-variables approach is useful as an auxiliary functional-form check, but it does not recover this joint distribution of latent resources, developmental states, family histories, and permanent heterogeneity. Section 6 reports that comparison.

4.5 Summary of structural restrictions

Table 1 summarizes the main inclusion and exclusion restrictions that give the counterfactuals their interpretation. The table distinguishes variables that shift initial conditions or family propensities from variables that enter the subsequent response technologies directly.

5 Estimation

We estimate the model by maximum likelihood. The likelihood combines four sources of uncertainty: (i) the continuous resource, skill, and investment states are latent; (ii) some family arrangements are unobserved; (iii) two resource indicators are binary; and (iv) permanent family type is unobserved. The derivation proceeds by first conditioning on a complete family path and permanent type, recursively evaluating the measurement likelihood along that path, and then integrating over the family paths and types that could have generated the observed history. This permits us to use all available measurements without first constructing factor scores or assigning children to latent types.

Below, we summarize the likelihood and the treatment of incomplete observations.

5.1 Individual likelihood contribution

Let Y_i collect all observed resource, skill, investment, and adult-outcome measurements for child i. Let ϑ denote the model parameters, let $\mathcal{F}_i$ denote the complete family histories compatible with the child's observed family information, and let $L_i^c(Y_i \mid f_i, k; \vartheta)$ denote the likelihood of the observed measurements conditional on family path f_i and permanent type k. The individual contribution is

$$L_i(\vartheta) = \sum_{k=0}^{1} \pi_k \sum_{f_i \in \mathcal{F}_i} \Pr(f_i \mid T_i = k, X_i; \vartheta) L_i^c(Y_i \mid f_i, k; \vartheta), \tag{21}$$

where $\pi_1 = \pi$ and $\pi_0 = 1 - \pi$. For a complete family path $f_i = (f_{i5}, f_{i7}, f_{i9}, f_{i11}, f_{i13})$, its conditional probability is

$$\begin{aligned} \Pr(f_i \mid T_i = k, X_i; \vartheta) = {} & \Pr(F_{i5} = f_{i5} \mid T_i = k, X_i; \vartheta) \\ & \times \prod_{t \in \{7,9,11,13\}} \Pr(F_{it} = f_{it} \mid F_{i,t-2} = f_{i,t-2}, T_i = k, X_i; \vartheta). \end{aligned} \tag{22}$$

Each term is evaluated using the multinomial-logit probabilities in (9). Thus, a path receives greater weight when its initial family arrangement and subsequent transitions are more likely

given the child's observed background characteristics, permanent type, and preceding family arrangements.

Conditional on f_i and k, the measurement likelihood can likewise be written as a sequence of predictive contributions,

$$L_i^c(Y_i \mid f_i, k; \vartheta) = \prod_{t \in \{5,7,9,11,13\}} p(Y_{it}^{obs} \mid Y_{i,<t}^{obs}, f_i, T_i = k, X_i; \vartheta) \times p(Q_i^{obs} \mid Y_i^{obs}, f_i, T_i = k, X_i; \vartheta), \tag{23}$$

where Y_{it}^{obs} denotes the measurements observed at age t and Q_i^{obs} denotes the available adult outcomes. The sample log likelihood is $\sum_i \log L_i(\vartheta)$. Equations (21) and (23) make explicit that missing family arrangements are not imputed and children are not assigned to a permanent type before estimation. Instead, the likelihood integrates over all compatible family histories and both permanent types, weighting each possibility by its estimated probability.

5.2 Filtering the continuous latent states

Conditional on a family path and permanent type, the resource, skill, and investment system is linear Gaussian. We therefore use the Kalman filter to evaluate the likelihood contributions from the continuous measurements. Filtering is needed because the latent states are never observed directly. At each age, the filter combines the distribution predicted from earlier ages with the new, noisy measurements observed at the current age. It then carries the resulting updated distribution forward to the next age, preserving uncertainty about the latent states throughout the childhood history.

Let $S_{it} = (R_{it}, C_{it}, I_{it}, N_{it})'$ and suppose that, immediately before incorporating the age-t measurements, its conditional distribution is

$$S_{it} \mid \mathcal{H}_{it}^-, f_i, T_i \sim N(m_{it}^-, P_{it}^-),$$

where $\mathcal{H}_{it}^-$ contains the measurements observed before the current update. The superscript $-$ denotes the predicted mean and covariance before the age-t measurements are incorporated, while the superscript $+$ denotes their filtered values after those measurements are incorporated. Thus, $m_{i,t-1}^+$ and $P_{i,t-1}^+$ summarize the information available after processing the measurements at the preceding age.

The initial predictive mean depends on the child's covariates, age-5 family arrangement, and permanent type. At later ages, the transition equations map the preceding filtered moments into the new predictive moments. In compact form,

$$m_{it}^- = d_{it}(f_i, T_i, X_i) + A_t m_{i,t-1}^+, \qquad P_{it}^- = A_t P_{i,t-1}^+ A_t' + \Omega_t, \tag{24}$$

where A_t is the transition matrix for the complete state vector and Ω_t is the covariance matrix of its innovations. The matrix A_t contains resource persistence, the elements of the developmental transition matrix G_t defined in Section 3, and the additional links implied by the recursive ordering of resources, skills, and investment. The response parameters in A_t and the innovation covariance matrix Ω_t are common across permanent types.

The continuous measurements observed at age t have the representation

$$Y_{it}^{G} = a_{it} + H_{it} S_{it} + e_{it}, \qquad e_{it} \sim N(0, V_{it}). \tag{25}$$

The corresponding predictive normal density contributes to the likelihood. Its forecast error then updates m_{it}^{-} and P_{it}^{-} to the filtered moments m_{it}^{+} and P_{it}^{+}. The matrices H_{it} and V_{it} contain only the indicators observed for that child at that age. For the adult outcomes, the conditional means are evaluated at the filtered age-13 posterior means of cognitive and noncognitive skills. The adult likelihood then uses the estimated adult-outcome disturbance variances; the current implementation does not add the remaining filtered age-13 latent-state variance to the adult predictive variance. Thus, the childhood likelihood uses the complete history of available indicators while accounting for measurement error and uncertainty about the latent states throughout the childhood process, while the adult contribution is conditional on the filtered age-13 posterior means.

5.3 Binary resource measurements

SNAP receipt and private insurance require an additional step because their measurement equations are probits rather than Gaussian regressions. Write a generic binary resource indicator as

$$D_{it} = \mathbf{1}\{D_{it}^{*} > 0\}, \qquad D_{it}^{*} = a_{Dt} + b_D R_{it} + u_{it}^{D}, \qquad u_{it}^{D} \sim N(0,1).$$

For SNAP, $a_{Dt} = \tau_t$ and $b_D = -\lambda_S$; for private insurance, $a_{Dt} = \kappa_t$ and $b_D = \lambda_H$. If the current conditional distribution of resources is $N(m_R, P_R)$, the predictive probability of observing $D_{it} = d$ is

$$\Pr(D_{it} = d \mid \mathcal{H}_{it}^{-}) = \Phi\left[\frac{(2d-1)(a_{Dt} + b_D m_R)}{\sqrt{1 + b_D^2 P_R}}\right]. \tag{26}$$

This probability enters the likelihood directly, so the binary variables are not converted into continuous scores.

Observing SNAP receipt or private insurance changes the conditional mean and variance of

the latent resource state. For example, SNAP receipt generally shifts the conditional resource distribution downward, whereas private insurance coverage shifts it upward. Conditioning on a binary outcome, however, produces a non-Gaussian posterior distribution. The first two conditional moments of that distribution are available analytically from the corresponding truncated-normal formulas. We approximate the posterior by a Gaussian distribution with the same conditional mean and variance and then continue the filtering recursion. This retains the information about resources contained in the binary observation while preserving the Gaussian form required for the subsequent filtering steps. Through the covariance of resources with the other latent states, the binary observation can also update the conditional distributions of skills and investment. Income, SNAP, and insurance consequently inform one common resource factor while retaining measurement models appropriate to their different scales.

5.4 Missing measurements and family arrangements

The likelihood uses every observed indicator but does not require a complete set of measurements at every age. For the continuous measurement update in (25), rows corresponding to unavailable indicators are omitted from Y_{it}^{G}, H_{it}, and V_{it}. A missing SNAP or insurance observation similarly contributes neither the probability in (26) nor a moment update. The latent state is nevertheless propagated to the next modeled age using (24). Information observed before and after the missing item therefore continues to contribute to the child's likelihood.

Missing family arrangements are handled differently because family state enters the transition system rather than only the measurement system. For each child, $\mathcal{F}_i$ contains every complete five-age family path that matches the child's recorded family arrangement at each age for which that arrangement is observed. If F_{it} is observed, paths containing either of the other two states at age t receive zero weight. If it is missing, all three states remain possible, and their weights are determined by the initial or transition probabilities implied by the model and by how well the resulting path explains the child's resource and developmental measurements. The inner sum in (21) integrates exactly over these compatible paths. This approach avoids assigning an unobserved arrangement from adjacent observations and avoids discarding children with an otherwise informative history.

The maintained missing-data assumption is that, conditional on the variables and histories included in the likelihood, whether a particular indicator or family arrangement is observed carries no additional information about its unobserved value. Patterns of measurement availability are described in Section 2.

5.5 Integration over permanent type

The outer sum in (21) integrates over the two permanent types. For each type, the likelihood is evaluated using that type's shifts in the initial states and family propensities and then weighted by its population probability. A child's posterior probability of type k is

$$\begin{aligned} \Pr(T_i = k \mid Y_i, F_i^{obs}, X_i) &= \frac{\pi_k L_{ik}(\vartheta)}{\sum_{h=0}^{1} \pi_h L_{ih}(\vartheta)}, \\ L_{ik}(\vartheta) &= \sum_{f_i \in \mathcal{F}_i} \Pr(f_i \mid T_i = k, X_i; \vartheta) L_i^c(Y_i \mid f_i, k; \vartheta). \end{aligned} \tag{27}$$

These posterior probabilities are an output of the joint estimation rather than an input or a preliminary classification. A child may therefore contribute to both mixture components when the observed history does not sharply distinguish them.

We maximize the observed-data likelihood in (21) directly. The two type-specific contributions are evaluated and summed at every parameter vector considered by the optimizer. Estimation therefore does not use an expectation-maximization algorithm with separate type-classification and parameter-updating steps.

The mixture is also evaluated jointly with the common response technology. Type-specific initial conditions and family propensities account for persistent differences across family histories, while the resource, investment, and skill-response coefficients are estimated from the full sample under the restriction that they are shared across types. This is important for the counterfactual interpretation: the model integrates over uncertainty about permanent family type, but it does not obtain different treatment effects by assigning separate production technologies to the two groups. Counterfactual aggregation and posterior weighting are described at the beginning of Section 6.

6 Structural Evidence

6.1 Developmental technology and financial resources

Models of skill formation require an empirical representation of the family inputs that contribute to child development. Influential work represents income and observed features of the home environment through a common latent parental-investment factor (Cunha and Heckman, 2008; Cunha et al., 2010; Agostinelli and Wiswall, 2025). In Cunha and Heckman (2008), for example, family income is among the observed proxies for that factor and is used to normalize its scale. Income-related variation therefore enters their skill technology through the broader investment input rather than through a separate income coefficient. Our model

instead distinguishes financial resources from measured parental investment. The resource state, R_t, is measured by family income, SNAP receipt, and private health insurance; the investment state, I_t, is measured by parental activities and features of the home environment. Thus, R_t and I_t are separate states rather than alternative measures of the same input.

This distinction allows financial resources to affect children by changing measured parental investment,

$$R_t \longrightarrow I_t \longrightarrow (C_{t+2}, N_{t+2}).$$

It also permits additional relationships between the broader resource environment and children's skills that are not absorbed by the available investment measures. The preferred specification therefore includes the contemporaneous paths

$$R_t \longrightarrow C_t \qquad \text{and} \qquad R_t \longrightarrow N_t,$$

where "direct" refers to the ordering of the model rather than to a particular economic mechanism. These coefficients capture the association between the broader resource state and skills that remains after accounting for the investment indicators observed in the data.

6.2 Dynamic estimates and functional-form evidence

Table 6 reports selected estimates from the developmental system. We express the coefficients in population-standard-deviation units so that their magnitudes can be compared across latent states and ages. The table first reports how cognitive skill, noncognitive skill, and parental investment at one modeled age predict these states two years later. It then reports the contemporaneous relationships between financial resources and each developmental state.

The estimates display strong self-productivity. A one-standard-deviation difference in cognitive skill at the beginning of a two-year interval predicts between 0.53 and 0.94 standard deviations higher cognitive skill at the end of the interval. Cognitive persistence rises with age. Noncognitive self-productivity is also substantial and comparatively stable, ranging from 0.78 to 0.89. Investment is persistent as well: its standardized own-state coefficient is 1.07 from ages 5 to 7, falls to 0.64 from ages 7 to 9, and is approximately one in the two later transitions. These patterns are broadly consistent with the dynamic skill-formation literature's emphasis on self-productivity and the cumulative importance of early states (Cunha and Heckman, 2008; Cunha et al., 2010).

Cross-productivity in the skill equations is limited. Across the four transitions, the standardized effects of parental investment and prior noncognitive skill on subsequent cognitive skill are small. The effects of prior cognitive skill and parental investment on subsequent

noncognitive skill are similarly modest. In absolute value, none of these cross-effects exceeds 0.061. The evolution of both skills is therefore driven much more by self-productivity than by dynamic spillovers from the other developmental states.

This aspect of the estimates differs from Agostinelli and Wiswall (2025), who find that parental investment is especially productive in producing cognitive skills during early childhood. The difference does not arise simply from the data or age range: both studies use the CNLSY, examine similar childhood ages, and employ overlapping measures of parental investment. Instead, the models allocate developmental influence differently. Agostinelli and Wiswall estimate a nonlinear cognitive-skill technology that allows the productivity of investment to depend on the child's existing skill, while family income helps determine the investment process. We jointly model cognitive skill, noncognitive skill, and investment using a linear dynamic technology and distinguish measured parental investment from a separate multidimensional resource state. The comparison therefore concerns how related family inputs are represented within the developmental system, not whether parental behavior matters for children.

A possible concern is that the small cross-skill and investment coefficients reflect the linear specification of the skill technologies. To examine this possibility, we estimate auxiliary linear and translog technologies using the sequential instrumental-variables methods of Agostinelli and Wiswall (2025) and Del Bono et al. (2022). Both specifications use the same three family arrangements, observed-income measure, instrument structure, and estimation samples. We compare the linear coefficients with average marginal effects from the translog model using a paired bootstrap that resamples mothers and applies the same draw to both specifications. The two technologies produce the same substantive pattern: strong persistence in cognitive and noncognitive skills and comparatively small cross-skill and investment effects. None of the 24 corresponding technology differences is statistically distinguishable from zero. Appendix Table A.5 reports the estimates and bootstrap comparisons. Although this auxiliary exercise does not reproduce the latent resource state, permanent types, or complete family process of the structural model, it indicates that the principal conclusions about skill dynamics are not artifacts of the linear functional form.

Financial resources are highly persistent across childhood, with an estimated autoregressive coefficient of 0.929. Residence with a lone mother rather than with the mother and biological father is associated with lower resources at every modeled age, conditional on observed characteristics and permanent type. The difference is especially large at age 5—approximately three-quarters of a standard deviation—but remains negative thereafter. Both the persistence coefficient and all five lone-mother coefficients are precisely estimated. Because a resource difference at one age carries forward into subsequent periods, these age-specific coefficients

describe changes in the resource path rather than independent effects at each age. Section 7 therefore uses counterfactual simulations to quantify their cumulative consequences for children's development.

Residence with a social father or partner has a less uniform relationship with resources. Relative to residence with both biological parents, the association is negative at age 5, positive at several later ages, and approximately zero at age 9. The estimates also vary in precision across ages. This pattern supports treating social-father residence as a distinct family arrangement: its resource environment does not follow either the biological-parent or lone-mother profile consistently over childhood.

The direct family coefficients in the investment equations are smaller and less systematic. Relative to biological-parent residence, the lone-mother coefficients alternate in sign and range from -0.060 to 0.027 in latent investment units. The social-father coefficients are similarly mixed, except for a larger positive coefficient at age 13. The estimates therefore provide little evidence of a uniform direct reduction in the measured investment factor following lone-mother residence once resources, prior states, observed characteristics, and permanent type are held fixed.

These results complement evidence that family change affects several margins simultaneously. Chan and Liu (2025) emphasize paternal time and relationship quality, together with selection into family arrangements. Our estimates identify a particularly persistent resource margin and show that it is not well summarized by the available investment indicators. The two findings are not competing accounts: family transitions can change relationships and parental time while also producing a resource path that has its own association with child development. More generally, the persistent resource losses associated with lone motherhood accord with family-structure research that identifies economic circumstances as an important mediator of children's outcomes (Carlson and Corcoran, 2001; Lopoo and DeLeire, 2014; Hastings, 2021).

The relationship between resources and child development is strongest at age 5. A one-standard-deviation increase in resources at that age is associated with roughly one-quarter of a standard deviation higher cognitive skill, noncognitive skill, and parental investment. At later ages, the contemporaneous relationships with both skills are smaller and vary in precision, although positive associations remain evident at several ages. The relationship between resources and measured parental investment is different: after age 5, the estimates are small, sometimes negative, and not statistically distinguishable from zero. Thus, early resources are associated with both the investment environment observed in the data and children's skills, whereas later resource differences are related primarily to skills through pathways not captured by those investment measures. Because resources and skills are persistent, this

age pattern does not imply that later outcomes depend only on contemporaneous resources; differences arising earlier can continue to affect development through the subsequent evolution of both states.

Positive resource effects are consistent with evidence from income changes generated by policy and other plausibly exogenous variation (Akee et al., 2010; Duncan et al., 2011; Dahl and Lochner, 2012). Our estimates add two qualifications to that evidence. Resources are measured more broadly than current income, and the effect of a resource difference depends on the age at which it occurs and the subsequent persistence of the resource and skill states.

6.3 Measurement reliability

Appendix Table A.4 reports observed-pattern reliability for the latent developmental states. Cognitive and noncognitive skills are measured relatively precisely, whereas parental investment is measured less precisely. This pattern is consistent with earlier skill-formation evidence that observed measures of parental inputs contain substantial measurement error (Cunha and Heckman, 2008; Cunha et al., 2010). It reinforces the value of treating the observed activities and home-environment measures as noisy indicators of a latent investment state rather than as error-free inputs. The complete dynamic model additionally uses persistence and measurements observed at earlier and later ages.

6.4 Permanent heterogeneity and family selection

The estimated population shares of the two permanent types are relatively balanced, with type 1 accounting for 55 percent of the sample. The types differ little in their initial cognitive skill, noncognitive skill, or parental investment. Differences are more apparent in initial resources and, especially, in the persistent propensities to occupy the three family arrangements. Permanent type therefore captures heterogeneity in family and resource histories much more strongly than heterogeneity in children's initial developmental states. Because the family-state parameters are latent-index coefficients, their magnitudes should not be interpreted directly as probability differences.

The pattern is nevertheless informative about the role of permanent type. The mixture primarily separates families with different persistent propensities for family arrangements and different initial resource environments; it does not uncover sharply separated initial skill groups. Moreover, the skill, investment, and resource technologies are common across types. Type consequently addresses persistent selection into family histories without presuming that otherwise comparable children respond differently to the same resource change.

This interpretation is consistent with a broad family-structure literature stressing that

parents who enter and leave different arrangements differ before the transition occurs (McLanahan and Sandefur, 1994; McLanahan et al., 2013; Lee and McLanahan, 2015). It is also closely related to the role of heterogeneity in Chan and Liu (2025). Our finite mixture summarizes this persistent selection within a longer-horizon model of resource and skill dynamics. Its purpose is not to attach substantive labels to two kinds of families, but to prevent stable differences in family trajectories and initial conditions from being attributed mechanically to a change in current family arrangement.

6.5 Family-process fit

Because the family-transition counterfactual relies on the estimated law of motion for family states, an important diagnostic is whether the family process reproduces the persistence and transitions observed in the data. Appendix Table A.6 compares observed family arrangements and transitions with their model-predicted counterparts. The fit is close: across the transitions among the three family arrangements, the average absolute discrepancy is only 1.3 percentage points, and the model reproduces the strong persistence of each arrangement. The initial age-5 distribution is somewhat harder to match because no earlier family history is available, but the discrepancies remain small. These results indicate that the permanent types and transition equations provide a useful representation of the family trajectories relevant to the counterfactual analysis.

6.6 Childhood skills and adult outcomes

Cognitive and noncognitive skills at age 13 both predict adult schooling and wages. A one-standard-deviation increase in cognitive skill is associated with approximately 0.25 log points higher wages and 1.07 additional years of schooling. The corresponding associations for noncognitive skill are about 0.08 log points and one-half year of schooling. All four relationships are statistically distinguishable from zero. Cognitive skill has the larger association with both outcomes, but noncognitive skill makes an independent contribution, consistent with evidence that both dimensions of capability predict educational and labor-market attainment (Heckman et al., 2006). In the model, these equations provide the link through which differences in childhood resource and skill paths produce consequences for adult outcomes.

6.7 Predictive fit

Before turning to the counterfactuals, we examine whether the estimated model reproduces important features of the observed data. Table 7 summarizes predictive fit across the resource,

investment, cognitive, noncognitive, and adult-outcome domains, while Appendix Table A.7 provides additional diagnostics for selected measurement outcomes.

The model reproduces the resource measurements particularly closely and captures the main age patterns in the cognitive indicators and the dispersion of the investment and noncognitive measures reasonably well. Predicted adult wages are close to their observed values, while completed schooling is overpredicted by 0.08 years. The remaining discrepancies are concentrated in a limited number of individual childhood measures rather than a common domain. Together with the family-process fit discussed above, these diagnostics indicate that the model provides a reasonable empirical representation of the histories used in the counterfactual analysis.

7 Counterfactuals

7.1 A transition into lone motherhood after biological-parent residence

Our main family counterfactual is designed to isolate a change in family arrangement from differences in family circumstances that are already present at the beginning of the modeled childhood period. In both counterfactual worlds, the child resides with the mother and biological father at age 5, $F_5 = B$. In the baseline world the child remains in that arrangement at age 7, $F_7 = B$, whereas in the treatment world the child moves into lone-mother residence, $F_7 = L$. From ages 9 onward, family arrangements evolve endogenously according to the estimated transition process. The probabilities of the forced age-5 and age-7 states are conditioned out, while predetermined characteristics and permanent type are held fixed. We integrate exactly over all subsequent family paths. Thus, the experiment compares

$$B_5 \to B_7 \qquad \text{with} \qquad B_5 \to L_7,$$

rather than comparing children who begin the modeled period in different family arrangements.

This distinction matters for interpretation. The earlier age-5 assignment experiment, considered below as a timing exercise, changes the child's family arrangement at the first modeled age and therefore also changes the initial resource and developmental environment generated by the model. The age-7 experiment instead starts both worlds from the same age-5 family arrangement and introduces the family transition only after that common initial condition. It is consequently our preferred experiment for describing the modeled consequences of a transition into lone motherhood during childhood. The one-type versus two-

type comparison reported below pertains instead to the age-5 assignment. It is informative about persistent selection in that early family-state contrast, but it does not establish that permanent heterogeneity would reduce the clean age-7 transition effect by the same proportion.

The transition produces an immediate deterioration in the resource environment. At age 7, resources are 0.147 population standard deviations lower in the lone-mother world. The resource gap then becomes more persistent, reaching 0.204 standard deviations at age 9 and approximately 0.21 standard deviations at ages 11 and 13. The skill effects are initially much smaller but accumulate over childhood. Cognitive skill is 0.011 standard deviations lower at age 7, 0.017 lower at age 9, 0.030 lower at age 11, and 0.033 lower at age 13. The corresponding noncognitive effects grow from -0.008 at age 7 to -0.041 standard deviations at age 13. Measured parental investment falls by 0.040 standard deviations at the time of the transition but shows little net difference by age 13. The age-13 skill differences imply 0.057 fewer years of completed schooling and 0.011 lower adult log wages.

The dynamic path is informative. The family transition generates a resource difference that persists and widens after the initial change, while the cognitive and noncognitive differences accumulate gradually. The adult consequences therefore do not arise from a large contemporaneous skill response at age 7. They reflect the propagation of a persistent difference in the childhood environment through the subsequent developmental system.

7.2 Mechanisms linking the transition to child outcomes

To understand why the age-7 transition affects children, we decompose its consequences into three pathways under the timing and exclusion assumptions stated in Section 4. First, family structure changes financial resources, and current resources can enter cognitive and noncognitive skills directly within the model. Second, resources can change measured parental investment, which can then affect later skills. Third, family arrangement can change investment directly even conditional on resources, with those investment differences subsequently affecting skills. Because these pathways operate jointly and can interact, we use an exact three-channel Shapley decomposition: each channel is introduced in every possible ordering and its marginal contributions are averaged. The resulting components add exactly to the total effect apart from numerical rounding.

The decomposition shows that the dominant pathway is the relationship between the resource state and skills outside measured parental investment. At age 13, the total effects on cognitive and noncognitive skills are -0.033 and -0.041 standard deviations. The direct resource-to-skill Shapley components are -0.031 and -0.039, respectively. The resource-to-

investment pathway contributes only about +0.001 standard deviations to each skill, while the direct family-to-investment pathway contributes approximately −0.003 to cognition and −0.002 to noncognition.

The same pattern carries into adulthood. Of the total schooling effect of −0.057 years, −0.054 is attributed to the direct resource-to-skill pathway, +0.001 to the resource-to-investment pathway, and −0.004 to the direct family-to-investment pathway. For adult log wages, the corresponding components are −0.0107, +0.0002, and −0.0009, compared with a total effect of −0.0114. The direct resource-to-skill pathway therefore accounts for roughly 94 percent of both adult effects in this model-based decomposition.

The investment results are useful for interpreting this allocation. By age 13, the resource-to-investment channel contributes about +0.040 standard deviations to investment, whereas the direct family-to-investment channel contributes about −0.036. These effects largely offset, leaving a small net age-13 investment difference of about +0.003 standard deviations. The skill effects nevertheless remain negative because the persistent resource shortfall enters the cognitive and noncognitive equations directly within the maintained specification.

The word "direct" here refers to the structure of the estimated model, not to a claim that money or insurance mechanically produces skills without intervening behavior. The latent resource state is measured jointly by family income, SNAP receipt, and private health insurance. Its direct coefficients capture resource-linked features of the child's environment that remain associated with skills after conditioning on the parental-investment indicators available in the CNLSY. Those features could include inputs, constraints, stability, stress, neighborhood circumstances, or parental behaviors that are not represented by our measured investment factor. The decomposition therefore indicates that the observed investment measures account for little of the developmental effect associated with the estimated resource path; it does not identify the specific unmeasured mechanisms underlying the resource-to-skill relationship.

This allocation differs in emphasis, rather than necessarily in substance, from related findings. Chan and Liu (2025) highlight paternal involvement and relationship quality, dimensions that are observed in their data but are not separately represented in our investment state. Earlier family-structure research also assigns an important mediating role to economic circumstances and the home environment (Carlson and Corcoran, 2001; Lopoo and DeLeire, 2014; Hastings, 2021). Family transitions can change relationships, parental time, and investment while also generating a persistent resource loss. Our contribution is to quantify the relative importance of the resource and measured-investment pathways within a common dynamic system.

7.3 Consequences of a change in financial resources

The model identifies responses to changes in R_t; expressing those changes in dollars requires an additional mapping. For a household with baseline income Y_{it}, we map a cash increment D_{it} into the resource state through the unit income loading:

$$\Delta R_{it}(D_{it}) = \log(Y_{it} + D_{it}) - \log Y_{it}. \tag{28}$$

The fitted family path is held fixed, and SNAP receipt and private insurance are not mechanically reassigned. The experiment therefore asks what the estimated resource technology predicts when a cash-induced change in log income shifts the broader latent resource index by the amount implied by its income anchor.

We consider both a one-time increment at age 5 and repeated increments at ages 5, 7, 9, 11, and 13. A one-time \$10,000 increment at age 5 raises age-13 cognitive and noncognitive skills by 0.087 and 0.111 standard deviations, respectively. The model predicts an increase of 0.152 years in completed schooling and 0.030 log points in adult wages. Repeating the \$10,000 increment at all five modeled ages produces larger effects: age-13 cognitive and noncognitive skills increase by 0.165 and 0.217 standard deviations, completed schooling rises by 0.293 years, and adult log wages increase by 0.058. The repeated intervention represents a total nominal increment of \$50,000 distributed across childhood.

A family transition and a one-time resource intervention are therefore different counterfactual objects even though resources are the principal modeled mechanism linking the transition to skills. The family transition generates an endogenous resource path and also changes family-state and investment histories. The resource intervention changes the resource state while holding the family path fixed. The comparison is useful for understanding the dynamic role of resources, but it should not be interpreted as equating a change in family structure with a cash transfer.

The estimates are precise relative to their magnitudes. The parametric-bootstrap confidence intervals exclude zero for the cognitive, noncognitive, schooling, and wage effects of every age-5 and repeated resource intervention reported in Table 13. This does not make the smaller changes economically large, but it indicates that their signs are not driven by local parameter uncertainty in the estimated model.

The one-time resource effects are almost identical in the one- and two-type specifications. Appendix Section B.6 reports this comparison. Permanent heterogeneity changes the estimated consequences of changing family state by separating persistent selection from response, but it does not materially change the common developmental technology applied to an externally imposed resource increment.

Although the repeated intervention provides five times as many nominal dollars as the one-time increment, its effects are less than five times as large. Timing is central to this difference. The age-5 increment affects development throughout the remaining childhood horizon, whereas increments received at later ages have fewer periods in which to influence skills and adult outcomes. In addition, a fixed dollar increment produces a smaller change in log income—and therefore in the latent resource state—for families with higher baseline income. The consequences of a cash increment thus depend not only on its dollar amount, but also on when it is received, the household's initial resources, and the time available for its effects to accumulate.

The results are broadly consistent with evidence that income changes can improve children's outcomes, while emphasizing that estimated effects depend on the duration and timing of exposure. Duncan et al. (2011) and Dahl and Lochner (2012) study changes in annual family income and outcomes measured relatively close to those changes. Akee et al. (2010), by contrast, examine a larger recurring transfer and document longer-run gains in schooling, particularly among children from initially disadvantaged households. Our simulations connect these findings within a common developmental framework: an early resource increase has more time to propagate through childhood, while sustained increases produce larger total effects by altering the resource path over several developmental periods.

The findings also help interpret the limited effects on child outcomes reported by Krause et al. (2026). Their randomized experiment provides causal evidence for a particular payment stream, population, set of outcomes, and follow-up period. Our simulations cannot reproduce that experiment because these dimensions differ, but they show why a positive developmental role for resources need not imply large detectable effects from every transfer within every observation window. The size and persistence of the resource change, the child's age when it occurs, and the horizon over which outcomes are measured all shape the resulting effect. Experimental and structural evidence are therefore complementary: the experiment identifies the consequences of a specific intervention, while the model helps interpret how those consequences may depend on scale, timing, and the dynamics of child development.

7.4 Timing and the complementary age-5 experiment

The clean age-7 transition is our preferred family experiment because both worlds share biological-parent residence at age 5. We nevertheless retain the earlier age-5 assignment and the broader onset exercises because they show how strongly the consequences depend on the age at which family paths begin to diverge. For onset at age 5, the baseline forces $F_5 = B$ and the treatment forces $F_5 = L$; subsequent family arrangements evolve endogenously. For

onset at ages 7, 9, and 11, the family history before onset is common across the two worlds, the current state is forced to B or L at the onset age, and later arrangements again evolve endogenously. The age-5 comparison should therefore be interpreted as an early family-state assignment rather than literally as an observed transition from B to L within the modeled period.

Table 14 shows a pronounced timing gradient. The age-5 assignment reduces age-13 cognitive and noncognitive skills by 0.196 and 0.250 standard deviations, completed schooling by 0.343 years, and adult log wages by 0.068. The clean age-7 transition produces much smaller effects: -0.033 and -0.041 standard deviations for the two skills, -0.057 years of schooling, and -0.011 log wages. The corresponding effects are smaller still for onset at ages 9 and 11. The resource loss at age 13 is not perfectly monotonic across the later onset ages because the relationship between family arrangement and resources varies with age, but the effects on skills and adult outcomes decline sharply as the developmental horizon shortens.

The large difference between the age-5 and age-7 experiments also reinforces why the two should not be given the same interpretation. The age-5 assignment changes the initial resource environment and, through the contemporaneous resource-to-skill coefficients, initial cognitive and noncognitive skills. Those initial differences then persist through the dynamic technology. In the clean age-7 experiment, by contrast, age-5 family arrangement and developmental states are common by construction; the skill differences begin only when the age-7 family and resource paths diverge. The age-5 exercise is therefore informative about the consequences of very early exposure, while the age-7 experiment provides the cleaner transition estimand.

We conduct a parallel resource experiment by providing the same one-time \$10,000 increment at ages 5, 7, 9, 11, or 13 while leaving family arrangements unchanged. A \$10,000 increment received at age 5 raises age-13 cognitive and noncognitive skills by 0.087 and 0.111 standard deviations, completed schooling by 0.152 years, and adult log wages by 0.030. When the increment is delayed until age 13, the effects fall to 0.006 and 0.014 standard deviations for the two skills, 0.014 years of schooling, and 0.003 log points in wages. The bootstrap intervals for all four age-5 effects exclude zero, whereas those for the developmental and adult effects of an increment arriving only at age 13 include zero. Earlier resources matter more because they can affect skills immediately and because those skill differences continue into subsequent developmental periods.

The distinction between the resource stock at a particular age and cumulative resource exposure is especially revealing. The \$10,000 increment actually produces a slightly larger resource difference at age 13 when it is delivered at age 13 rather than at age 5, because a recent increment has not yet dissipated. Its effect on skills and adult outcomes is nevertheless much smaller because it has had almost no time to enter the developmental process. Current

resources therefore provide an incomplete account of the resource environment experienced over childhood: two children with similar resources at age 13 can have very different earlier exposures and developmental histories.

Our results speak to the same timing and measurement questions studied by Eshaghnia et al. (2025), but the age patterns are not identical. They show that no single age provides the most informative measure of parental resources for every outcome and that resources received later in childhood can be especially important for outcomes linked to skills emerging during adolescence. In our model, by contrast, an identical one-time resource increment has larger effects on age-13 skills and adult outcomes when it is delivered earlier. This difference reflects both the outcomes considered and the developmental technologies represented in the two models. The common conclusion is not that early resources always dominate, but that current income at one age is an incomplete measure of the resource exposure relevant to child development.

The larger long-run benefits associated with sustained exposure in Akee et al. (2010) provide a related comparison. Our simulations add that interventions cannot be ranked solely by comparing resources at the terminal age. A later increment can leave a larger observed resource stock while producing smaller developmental effects because it has had less time to influence the skills represented in our model.

The counterfactual exercises therefore distinguish three objects. The clean age-7 experiment isolates a modeled transition into lone motherhood after a common age-5 family state. The age-5 and later-onset exercises show how the consequences vary with the developmental timing of family exposure. The resource experiments change financial resources while leaving family structure fixed. Taken together, they show that a family transition generates a persistent resource path, that the resulting skill effects accumulate dynamically, and that the developmental consequences of a given resource change depend strongly on when in childhood it occurs.

8 Conclusion

Family structure, financial resources, and child development evolve jointly over childhood, while families experiencing different histories can differ persistently before a transition occurs. This paper separates these dimensions in a dynamic model of three family states, a multidimensional financial resource state, parental investment, cognitive and noncognitive skills, and adult outcomes. Permanent latent family types allow for persistent selection on time-invariant unobserved characteristics associated with family histories and initial conditions.

Our preferred family counterfactual begins from a common initial condition: children reside with both biological parents at age 5 in both worlds, and at age 7 we compare remaining in that arrangement with a transition into lone motherhood. Subsequent family states evolve endogenously. The transition produces an immediate resource loss of 0.147 standard deviations that grows to about 0.215 standard deviations by age 13. Skill differences are initially small but accumulate, reaching 0.033 standard deviations for cognition and 0.041 for noncognitive skill at age 13. The implied adult effects are 0.057 fewer years of schooling and 0.011 lower log wages.

The model-based mechanism decomposition attributes most of these consequences to the persistent deterioration in the resource environment and its direct relationship with skills within the model. Roughly 94 percent of the adult schooling and wage effects is assigned to this resource-to-skill pathway. Bootstrap inference indicates that this dominant component is precisely estimated, whereas the pathways through measured parental investment are much smaller and generally imprecise. This finding should not be interpreted as a pure income mechanism: the resource factor combines income, SNAP receipt, and private insurance, and its direct skill coefficients can capture resource-linked inputs and constraints not represented by the investment indicators available in the CNLSY.

The complementary timing exercises show why the initial condition matters. Assigning lone-mother rather than biological-parent residence already at age 5 produces much larger effects because it changes the initial resource and skill environment and allows those differences to propagate throughout the modeled childhood period. In that age-5 experiment, allowing for permanent family heterogeneity reduces the estimated child and adult consequences by roughly one-quarter relative to an aligned one-type model. This comparison is evidence about the importance of persistent selection for the early family-state assignment; it does not imply that latent heterogeneity reduces the preferred age-7 transition effect by the same amount. The age-7 experiment instead holds the age-5 family state and developmental history common before the counterfactual paths diverge. Resource interventions display a parallel timing gradient: repeated increments produce larger effects than a single increment, and an identical one-time increment generally has larger developmental consequences when it arrives earlier and can propagate through more of childhood.

The contrast between the family and resource experiments also clarifies the role of persistent selection. Permanent heterogeneity substantially affects the estimated consequences of the age-5 family-state assignment, but the developmental response to an externally imposed age-5 resource increment is virtually unchanged between the one- and two-type specifications. The permanent-type structure does not, however, accommodate unrestricted time-varying unobservables that jointly alter family arrangements, resources, and child development; the

counterfactual interpretation therefore remains conditional on the sequential timing and exclusion assumptions of the model.

The results point to childhood financial resources as an important link between changing family environments and the accumulation of skills, while showing why the consequences of family change cannot be inferred directly either from observed family-structure gaps or from the effects of isolated resource interventions. Distinguishing persistent differences across families from the consequences of changing circumstances, and distinguishing a resource stock at one age from the resource path experienced over childhood, are both central to understanding how changing family environments are related to later outcomes.

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Tables

Table 1: Main structural assumptions and exclusion restrictions

Model component	Current family state	Permanent type	Maternal/background inputs	Main restriction / interpretation
Family process F_t	State outcome	Yes	Maternal age at birth, religious attendance, mother's adolescent lone-mother exposure, Black/Hispanic controls	First-order Markov in lagged family state after age 5; type shifts P and L destination propensities.
Initial resources R_5	Yes	Yes	Maternal education and C/N skills; grandparent education; mother's adolescent lone-mother exposure	Grandparent/family-origin variables enter the developmental system directly only through R_5.
Later resources R_t	Yes	No direct type shift	None of the grandparent/family-origin variables	Common persistence and family-state response process across permanent types.
Initial investment I_5	Yes	Yes	Maternal education and C/N skills; Black/Hispanic controls	Current R_5 enters directly; family state also has a direct investment coefficient.
Later investment I_t	Yes	No direct type shift	Maternal education and C/N skills	Lagged C, I, N and current R_t enter; current family state has a direct investment coefficient.
Initial skills C_5, N_5	No direct coefficient	Yes	Maternal C/N skills; Black/Hispanic controls	Current R_5 enters directly; no contemporaneous direct family-state or investment effect.
Later skills C_t, N_t	No direct coefficient	No direct type shift	Maternal C/N skills	Lagged C, I, N and current R_t enter; no direct family-state effect and no direct maternal-education or grandparent-background effect.
Adult schooling and wages	No	No	No direct background controls	Depend directly only on C_{13} and N_{13}; childhood states and background affect adulthood through terminal skills.

Notes: B (both biological parents) is the reference family state; P denotes residence with the mother and a social father or partner; L denotes residence with a lone mother. "Permanent type" indicates a direct type shift in the corresponding equation, not merely an indirect effect inherited from earlier states. All resource, investment, and skill response coefficients are common across permanent types in the preferred specification. Black and Hispanic indicators are included as observed controls in the age-5 developmental equations and family-state propensities; the paper does not estimate race-specific response technologies.

Table 2: Availability of childhood measures by age

Measure	Age 5	Age 7	Age 9	Age 11	Age 13
Any usable childhood information	2,971	2,973	2,974	2,972	2,973
Family					
Family arrangement	2,280	2,401	2,364	2,312	2,200
Cognitive skill					
PIAT mathematics	1,106	2,153	2,205	2,180	2,024
PIAT word recognition	1,079	2,150	2,198	2,181	2,026
PIAT reading comprehension	1,071	2,036	2,148	2,153	2,012
At least one cognitive measure	1,110	2,177	2,215	2,192	2,031
Noncognitive skill					
BPI antisocial behavior	2,078	2,179	2,247	2,216	2,116
BPI anxiety/depression	2,046	2,165	2,202	2,181	2,057
BPI headstrong behavior	1,863	2,031	2,040	2,046	1,928
At least one noncognitive measure	2,101	2,263	2,326	2,315	2,198
Parental investment					
Investment indicator 1	2,110	2,290	2,023	2,075	2,081
Investment indicator 2	2,104	2,285	2,357	2,345	2,208
Investment indicator 3	2,094	2,273	2,354	2,347	2,210
At least one investment measure	2,116	2,300	2,365	2,356	2,222
Financial resources					
Family income	2,412	2,390	2,315	2,192	2,063
SNAP receipt	2,956	2,959	2,951	2,944	2,947
Private child health insurance	2,139	2,327	2,384	2,385	2,282
At least one resource measure	2,971	2,973	2,973	2,968	2,971

Notes: The estimation sample contains 2,975 children. Entries are numbers of children with observed values. Investment indicators are reading, museum visits, and getting out of the home at age 5; reading, museum visits, and time with friends or family at age 7; and praise, museum visits, and time with friends or family at ages 9, 11, and 13. The likelihood uses all available observations and does not require a balanced panel.

Table 3: Family arrangements and adjacent-age transitions

	Age 5	Age 7	Age 9	Age 11	Age 13
Panel A: Family-arrangement shares					
Mother and biological father	0.729	0.676	0.625	0.566	0.565
Mother and social father/partner	0.043	0.075	0.101	0.125	0.128
Lone mother	0.227	0.249	0.274	0.309	0.307
Observed N	2,280	2,401	2,364	2,312	2,200

Panel B: Pooled adjacent-age transition probabilities				
Origin	B	P	L	Origin N
B	0.918	0.019	0.063	5,451
P	0.133	0.755	0.112	714
L	0.066	0.072	0.863	2,096

Notes: B denotes residence with the mother and biological father, P residence with the mother and a social father or partner, and L residence with a lone mother. Panel B pools the four adjacent-age intervals and reports row probabilities among children observed at both ends of an interval.

Table 4: Child-skill and parental-investment measures

Measure	Age 5	Age 7	Age 9	Age 11	Age 13
Cognitive					
PIAT mathematics	-1.421 (0.243)	-0.785 (0.489)	0.117 (0.610)	0.657 (0.600)	0.997 (0.634)
PIAT word recognition	-1.386 (0.258)	-0.719 (0.461)	0.076 (0.599)	0.630 (0.695)	1.028 (0.723)
PIAT reading comprehension	-1.398 (0.300)	-0.709 (0.505)	0.129 (0.616)	0.649 (0.684)	0.971 (0.739)
Noncognitive					
BPI antisocial behavior	0.031 (0.874)	-0.003 (0.954)	-0.011 (1.012)	0.029 (1.036)	-0.017 (1.073)
BPI anxiety/depression	0.089 (0.941)	-0.051 (0.999)	-0.081 (1.024)	-0.098 (1.038)	-0.103 (1.026)
BPI headstrong behavior	-0.078 (0.987)	-0.041 (0.990)	-0.011 (0.983)	0.007 (0.996)	0.000 (0.999)
Investment					
Investment 1	0.378 (0.880)	0.202 (0.920)	0.097 (1.028)	0.004 (0.991)	-0.128 (0.956)
Investment 2	0.013 (1.049)	0.126 (1.023)	0.133 (0.996)	0.069 (0.976)	-0.052 (0.956)
Investment 3	0.055 (0.984)	0.137 (0.969)	0.082 (0.983)	0.035 (0.988)	-0.052 (0.998)

Notes: Entries are means, with standard deviations in parentheses, for the transformed indicators used in estimation. Cognitive measures are standardized in the pooled sample across ages. Noncognitive and investment measures are standardized within age before applying item-specific missingness. Investment indicators are reading, museum visits, and getting out of the home at age 5; reading, museum visits, and time with friends or family at age 7; and praise, museum visits, and time with friends or family at ages 9, 11, and 13. Indicator-specific sample sizes are reported in Table 2.

Table 5: Observed measures of financial resources

	Age 5	Age 7	Age 9	Age 11	Age 13
Panel A: Means (standard deviations)					
Family income ($1,000s)	56.7 (44.9)	59.0 (45.9)	59.4 (46.0)	63.1 (47.3)	64.4 (49.1)
SNAP receipt	0.221 (0.415)	0.204 (0.403)	0.187 (0.390)	0.175 (0.380)	0.157 (0.364)
Private insurance	0.744 (0.437)	0.734 (0.442)	0.731 (0.443)	0.742 (0.438)	0.755 (0.430)
Panel B: Pairwise correlations					
Log income, SNAP	-0.537	-0.528	-0.536	-0.530	-0.491
Log income, private insurance	0.503	0.527	0.507	0.517	0.473
SNAP, private insurance	-0.500	-0.530	-0.533	-0.506	-0.502

Notes: Statistics use the item-specific nonmissing samples. Family income is in thousands of real 2012 dollars. Panel B uses log family income. SNAP and private insurance are binary, so their standard deviations and correlations use their zero–one coding. Sample sizes are reported in Table 2.

Table 6: Selected standardized technology coefficients

Path	Ages 5–7	Ages 7–9	Ages 9–11	Ages 11–13
$C_t \to C_{t+2}$	0.530	0.724	0.903	0.942
	(0.028)	(0.023)	(0.024)	(0.021)
$I_t \to C_{t+2}$	-0.030	0.062	0.012	0.016
	(0.034)	(0.022)	(0.019)	(0.019)
$N_t \to C_{t+2}$	0.029	0.042	0.004	0.022
	(0.027)	(0.019)	(0.016)	(0.016)
$C_t \to N_{t+2}$	-0.010	0.020	0.011	-0.060
	(0.032)	(0.023)	(0.024)	(0.026)
$I_t \to N_{t+2}$	0.005	0.038	0.010	0.029
	(0.038)	(0.031)	(0.028)	(0.029)
$N_t \to N_{t+2}$	0.782	0.840	0.884	0.854
	(0.042)	(0.038)	(0.035)	(0.034)
$I_t \to I_{t+2}$	1.070	0.645	1.005	1.017
	(0.058)	(0.062)	(0.078)	(0.073)

Path	Age 5	Age 7	Age 9	Age 11	Age 13
$R_t \to C_t$	0.255	0.075	0.034	0.066	0.019
	(0.036)	(0.030)	(0.022)	(0.018)	(0.018)
$R_t \to I_t$	0.280	-0.051	0.011	-0.065	-0.109
	(0.049)	(0.057)	(0.056)	(0.062)	(0.066)
$R_t \to N_t$	0.289	0.056	0.066	0.089	0.044
	(0.038)	(0.035)	(0.031)	(0.027)	(0.027)

Notes: Standard errors are in parentheses. Each entry gives the change in the outcome, measured in population standard deviations, associated with a one-population-standard-deviation increase in the input. Estimates and standard errors are rescaled by the same estimated population-SD ratio. The first seven coefficient rows describe two-year state transitions. The final three coefficient rows are contemporaneous resource coefficients. Measurement error is excluded from the population standard deviations.

Table 7: Predictive fit across measurement domains

Domain	Number of moments	Mean MAE	Standard-deviation MAE
Adult outcomes	2	0.041	0.025
Cognitive skill	15	0.023	0.028
Financial resources	15	0.016	0.016
Noncognitive skill	15	0.062	0.018
Parental investment	15	0.040	0.005

Notes: MAE is the mean absolute error between observed and predicted moments. Each childhood domain contains three indicators at each of five modeled ages. For binary resource indicators, the standard deviation is implied by the corresponding probability. Adult outcomes are log wages and completed schooling. Appendix Table A.7 reports maximum discrepancies and selected indicator-level comparisons.

Table 8: Family arrangements, resources, and investment

	Age 5	Age 7	Age 9	Age 11	Age 13
Panel A: Resource equation					
Social father or partner (P)	-0.130	0.166	-0.002	0.067	0.208
	(0.062)	(0.039)	(0.035)	(0.034)	(0.037)
Lone mother (L)	-0.533	-0.101	-0.122	-0.108	-0.134
	(0.037)	(0.024)	(0.025)	(0.025)	(0.026)
Panel B: Investment equation					
Social father or partner (P)	-0.056	-0.009	0.047	-0.044	0.135
	(0.078)	(0.063)	(0.044)	(0.048)	(0.053)
Lone mother (L)	0.025	-0.027	0.027	-0.060	-0.055
	(0.052)	(0.047)	(0.036)	(0.043)	(0.047)

Notes: Standard errors are in parentheses. The reference arrangement is residence with the mother and biological father (B). Entries are coefficients in the latent resource and investment equations and are therefore expressed in the units of the corresponding latent factor. The resource autoregressive coefficient is 0.929 (0.007).

Table 9: Main counterfactual: transition into lone motherhood at age 7

Evaluation age	Resources	Investment	Cognitive skill	Noncognitive skill
5	0.000	0.000	0.000	0.000
7	-0.147	-0.040	-0.011	-0.008
	(0.034)	(0.081)	(0.005)	(0.006)
9	-0.204	-0.000	-0.017	-0.022
	(0.031)	(0.056)	(0.008)	(0.008)
11	-0.214	-0.014	-0.030	-0.038
	(0.029)	(0.054)	(0.008)	(0.009)
13	-0.215	0.003	-0.033	-0.041
	(0.029)	(0.055)	(0.009)	(0.009)
Adult outcomes				
Completed schooling (years)			-0.057	(0.013)
Adult log wages			-0.0114	(0.0031)

Notes: Parametric-bootstrap standard errors are in parentheses and use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. Both counterfactual worlds force residence with the mother and biological father at age 5. The baseline forces biological-parent residence at age 7 and the treatment forces lone-mother residence at age 7. Family arrangements at ages 9, 11, and 13 evolve endogenously from the fitted transition process. Probabilities of the forced age-5 and age-7 states are conditioned out. Childhood effects are in preferred-model population standard deviations.

Table 10: Channel decomposition of the main age-7 family transition

Component	Cognition at 13	Noncognitive at 13	Schooling	Log wages
Total effect	-0.0330	-0.0408	-0.0571	-0.01140
	(0.0090)	(0.0092)	(0.0133)	(0.00313)
Direct resource-to-skill channel	-0.0307	-0.0394	-0.0539	-0.01070
	(0.0066)	(0.0086)	(0.0105)	(0.00261)
Resource-to-investment channel	0.0007	0.0007	0.0011	0.00022
	(0.0007)	(0.0008)	(0.0010)	(0.00021)
Direct family-to-investment channel	-0.0030	-0.0021	-0.0044	-0.00092
	(0.0063)	(0.0044)	(0.0088)	(0.00190)

Notes: Parametric-bootstrap standard errors are in parentheses and use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. Components are exact three-channel Shapley values for the $B_5 \to B_7$ versus $B_5 \to L_7$ experiment. The all-channels-off benchmark is zero for skills and adult outcomes, and the additivity residual is numerically zero. "Direct" refers to the ordering of the estimated model; the resource factor is measured by income, SNAP receipt, and private health insurance and should not be interpreted as income alone.

Table 11: Complementary age-5 family-state assignment: one- and two-type models

Outcome	One type	Two types	One-type exaggeration (%)
Age-13 resources (SD)	-0.866	-0.658	31.6
		(0.044)	
Age-13 cognitive skill (SD)	-0.242	-0.196	23.5
		(0.022)	
Age-13 noncognitive skill (SD)	-0.312	-0.250	25.0
		(0.030)	
Completed schooling (years)	-0.425	-0.343	24.1
		(0.039)	
Adult log wages	-0.085	-0.068	23.9
		(0.012)	

Notes: Parametric-bootstrap standard errors for the preferred two-type model are in parentheses. They use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. The baseline forces biological-parent residence at age 5 and the treatment forces lone-mother residence. Subsequent family states evolve endogenously. Standardized effects use the same preferred-model population standard deviations in both columns. This one-type versus two-type comparison pertains to the age-5 family-state assignment and should not be interpreted as a one-type versus two-type comparison of the preferred age-7 transition.

Table 12: Age-13 channel decomposition of the complementary age-5 family-state assignment

Component	Cognitive skill	Noncognitive skill
Total effect	-0.196	-0.250
	(0.022)	(0.030)
Direct resource-to-skill channel	-0.188	-0.242
	(0.023)	(0.029)
Resource-to-investment channel	-0.009	-0.009
	(0.006)	(0.006)
Direct family-to-investment channel	0.001	0.001
	(0.005)	(0.005)

Notes: Parametric-bootstrap standard errors are in parentheses. They use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. The baseline forces biological-parent residence at age 5 and the treatment forces lone-mother residence; subsequent family states evolve endogenously. Effects are in population standard deviations. Components are exact three-channel Shapley values and may differ from the total by rounding and the all-channels-off benchmark.

Table 13: Resource-only counterfactuals in the preferred model

Intervention	Cognition (SD)	Noncognitive (SD)	Schooling	Log wages
$1,000 once at age 5	0.010	0.013	0.018	0.0035
	(0.0009)	(0.0012)	(0.0015)	(0.0006)
$5,000 once at age 5	0.047	0.060	0.082	0.0163
	(0.0041)	(0.0054)	(0.0069)	(0.0026)
$10,000 once at age 5	0.087	0.111	0.152	0.0303
	(0.0075)	(0.0100)	(0.0128)	(0.0048)
$1,000 at each modeled age	0.022	0.030	0.040	0.0078
	(0.0029)	(0.0042)	(0.0045)	(0.0014)
$5,000 at each modeled age	0.095	0.125	0.169	0.0334
	(0.0118)	(0.0170)	(0.0186)	(0.0059)
$10,000 at each modeled age	0.165	0.217	0.293	0.0580
	(0.0198)	(0.0283)	(0.0314)	(0.0102)

Notes: Parametric-bootstrap standard errors are in parentheses. They use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. Family structure follows its natural fitted path in both worlds. Repeated interventions occur at ages 5, 7, 9, 11, and 13 and are scaling exercises, not representations of monthly transfers.

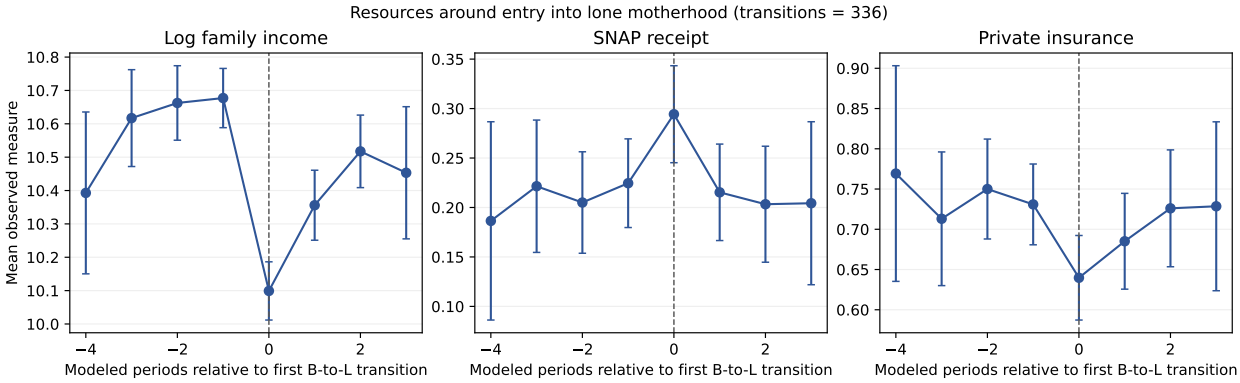


Figure 1: Resources around entry into lone motherhood

Notes: The figure reports means and 95-percent confidence intervals around the first observed transition from residence with the mother and biological father (B) to residence with a lone mother (L). Event time zero is the first modeled age in state L; adjacent event times correspond to two-year modeled periods. The number of observations varies by measure and event time. The figure is descriptive and does not identify a causal effect of the family transition.

Table 14: Timing of family and resource changes

Onset age	Resources at 13	Cognition at 13	Noncognitive at 13	Schooling	Log wages
Panel A: Lone-mother residence versus biological-parent residence					
5	-0.658	-0.196	-0.250	-0.343	-0.0682
	(0.0438)	(0.0225)	(0.0296)	(0.0386)	(0.0120)
7	-0.215	-0.033	-0.041	-0.057	-0.0114
	(0.0289)	(0.0090)	(0.0092)	(0.0133)	(0.0031)
9	-0.239	-0.023	-0.034	-0.042	-0.0083
	(0.0293)	(0.0067)	(0.0092)	(0.0105)	(0.0025)
11	-0.214	-0.016	-0.024	-0.029	-0.0057
	(0.0321)	(0.0054)	(0.0086)	(0.0088)	(0.0019)
Panel B: One-time $10,000 resource increment					
5	0.269	0.087	0.111	0.152	0.0303
	(0.0076)	(0.0075)	(0.0100)	(0.0128)	(0.0048)
7	0.272	0.048	0.058	0.082	0.0164
	(0.0064)	(0.0083)	(0.0102)	(0.0118)	(0.0032)
9	0.288	0.034	0.050	0.063	0.0124
	(0.0053)	(0.0070)	(0.0095)	(0.0101)	(0.0027)
11	0.293	0.025	0.034	0.045	0.0089
	(0.0045)	(0.0060)	(0.0091)	(0.0090)	(0.0022)
13	0.310	0.006	0.014	0.014	0.0025
	(0.0044)	(0.0053)	(0.0084)	(0.0074)	(0.0016)

Notes: Parametric-bootstrap standard errors are in parentheses. They use 500 accepted draws from the estimated asymptotic parameter distribution; fixed and boundary parameters are held at their point estimates. Resource, cognitive-skill, and noncognitive-skill effects are in population standard deviations; schooling effects are in years and wage effects are in log points. In Panel A, family arrangements follow their fitted natural distribution before onset; at onset, the baseline forces residence with the mother and biological father and the treatment forces lone-mother residence. Later arrangements evolve endogenously. In Panel B, family arrangements follow their natural fitted paths in both worlds. Values may differ slightly from calculations based on rounded entries.

Appendix

A Additional Descriptive Evidence

This section provides the additional descriptive evidence referenced in Section 2. Table A.1 reports each observed resource measure by family arrangement and age. Table A.2 compares predetermined background characteristics and age-5 developmental indicators across family arrangements observed at age 5. Figure A.1 presents an age-standardized version of the event-history profiles in Figure 1. These comparisons are descriptive and are not interpreted as causal effects of family arrangement.

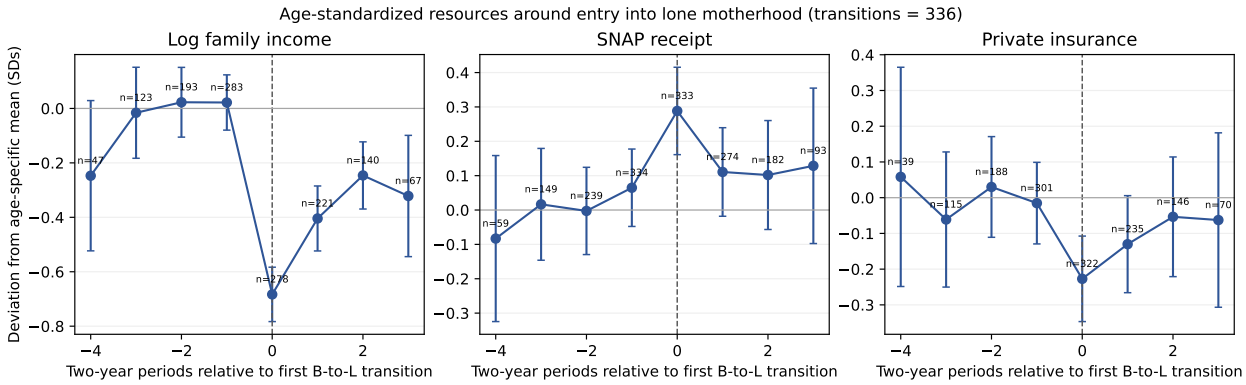


Figure A.1: Age-standardized resources around entry into lone motherhood

Notes: Each measure is expressed as a deviation from its age-specific mean in age-specific standard-deviation units. Event time zero is the first modeled age at which the child is observed residing with a lone mother after residence with the mother and biological father in the preceding modeled period. Labels report the number of observations contributing to each plotted mean. Vertical bars are 95-percent confidence intervals. The composition of the contributing sample varies across event times, and the profiles are descriptive rather than causal estimates.

B Measurement, Robustness, and Model Fit

This section collects supplementary evidence on the interpretation and measurement of parental investment, the reliability of the latent-factor measurement systems, the robustness of the skill technology to a translog specification, and the fit of the family-process and predictive moments.

Table A.1: Observed resource measures by family arrangement

Age	B	P	L
Family income (thousands of 2012 dollars)			
5	72.7	63.1	30.5
7	75.6	63.6	29.3
9	77.6	64.3	29.6
11	83.0	70.6	32.5
13	85.8	75.4	33.4
SNAP receipt			
5	0.088	0.162	0.428
7	0.085	0.107	0.431
9	0.086	0.135	0.406
11	0.075	0.121	0.399
13	0.075	0.089	0.378
Private insurance			
5	0.843	0.851	0.504
7	0.842	0.742	0.504
9	0.845	0.751	0.526
11	0.849	0.748	0.583
13	0.852	0.841	0.580

Notes: B denotes residence with the mother and biological father, P residence with the mother and a social father or partner, and L residence with a lone mother. Entries are means calculated on the item-specific nonmissing samples. SNAP receipt and private insurance are proportions. The underlying descriptive files report standard deviations and sample sizes.

Table A.2: Background and age-5 developmental measures by family arrangement

Variable	B	P	L
Background			
Black	0.165	0.182	0.510
Hispanic	0.201	0.212	0.210
Mother's cognitive skill	0.329	0.004	-0.217
Mother's noncognitive skill	0.138	-0.022	-0.110
Mother's education	0.228	-0.193	-0.094
Mother's age at birth	25.915	22.960	24.224
Mother's religious attendance	3.512	3.566	3.514
Mother raised by a lone mother	0.134	0.202	0.280
Family origin			
Maternal grandmother's education	10.816	10.200	10.210
Maternal grandfather's education	10.911	10.393	9.990
Age-5 cognitive skill			
PIAT mathematics	-1.402	-1.401	-1.483
PIAT word recognition	-1.369	-1.471	-1.413
PIAT reading comprehension	-1.378	-1.491	-1.430
Age-5 parental investment			
Investment 1	0.497	0.184	0.101
Investment 2	0.026	0.097	-0.043
Investment 3	0.128	0.056	-0.124
Age-5 noncognitive skill			
BPI antisocial behavior	0.108	-0.062	-0.137
BPI anxiety/depression	0.158	-0.049	-0.071
BPI headstrong behavior	-0.056	-0.215	-0.122

Notes: Columns classify children by their observed family arrangement at age 5. B denotes residence with the mother and biological father, P residence with the mother and a social father or partner, and L residence with a lone mother. The corresponding numbers of children are 1,663, 99, and 518, although indicator-specific samples can be smaller because of missing observations. Maternal skills and education and the child indicators are shown in their estimation units; grandparental education is in years. Means are descriptive and do not represent effects of family arrangement.

B.1 External time-use evidence on parental investment

The Children of the National Longitudinal Survey of Youth 1979 (CNLSY) provide repeated information over childhood but observe only selected dimensions of parental investment. We use the American Time Use Survey (ATUS) as an external measurement check: the question is whether participation in activities resembling the CNLSY investment indicators is associated with participation in a broader set of direct parent–child developmental activities. This comparison provides evidence on whether the relatively sparse CNLSY indicators are informative about a wider underlying pattern of parental investment.

The ATUS asks respondents to reconstruct the preceding day from 4 a.m. to 4 a.m. and records the detailed code of each activity. The accompanying "who" file identifies the household members present. We link these records to the household roster so that shared activities involve an own child in the relevant age range. Our primary sample covers 2003–2014, the years that overlap the later CNLSY childhood surveys, and contains female respondents with an own household child ages 5–13. The CNLSY-like participation measure indicates whether the mother reports reading with children, museum attendance, or shared social or leisure activity. We compare it with participation in a non-overlapping, broader measure of developmental investment that includes playing, arts and crafts, sports, talking and listening, educational assistance, attendance at children's events, and organization or planning for children.

Table A.3 reports survey-weighted correlations between participation in the CNLSY-like activities and participation in the broader developmental activities. The association is positive and substantial in the full sample and remains similar across child-age groups, in the sample with exactly one own child, and when the ATUS window is extended through 2019. The purpose of this exercise is not to compare investment levels across family arrangements. Rather, it asks whether the activities available in the CNLSY co-move with a broader set of parent–child developmental inputs in an independent time-use survey. The positive correspondence supports interpreting the CNLSY measures as indicators of a broader latent parental-investment construct. Any differences in the level of investment by family arrangement are examined directly in the CNLSY sample and are conceptually separate from this external measurement check.

B.2 Measurement reliability

Table A.4 summarizes the contemporaneous information supplied by the indicators used to measure each developmental factor. For each factor and age, reliability is one minus the ratio of the posterior factor variance to its prior variance, averaged over the indicator combinations

observed among children with at least one measurement in that domain. The estimates therefore summarize how much the contemporaneous indicators reduce uncertainty about the latent state, while the coverage column reports how often at least one same-domain indicator is available.

B.3 Instrumental-variables functional-form comparison

Table A.5 compares auxiliary linear and translog skill technologies. The calculations follow the sequential instrumental-variables strategy used by Agostinelli and Wiswall (2025) and Del Bono et al. (2022), updated so that both specifications use the same $B/P/L$ family classification and observed family income. The translog column reports average marginal effects evaluated over the corresponding estimation sample. The comparison is deliberately narrower than the structural model: resources are represented by observed income, and the procedure does not include permanent types or integrate over complete family and resource paths. Its purpose is to examine whether the pattern of self- and cross-productivity depends materially on imposing a linear skill technology.

B.4 Family-process fit

Table A.6 evaluates the discrete family process. Its fitted values are one-step-ahead predictions. At each age, the weights placed on the two permanent types incorporate the child's observed family history through the preceding age; the transition predictions additionally condition on the observed origin state. This updating is essential because a current family arrangement is itself informative about persistent selection into family histories.

B.5 Predictive-moment fit

Table A.7 provides additional diagnostics for the predictive-moment fit summarized in Section 6. It compares observed and model-predicted means and standard deviations of selected measurement outcomes across ages. The table complements the summary evidence in the main text by showing the fit for individual moments underlying those diagnostics.

B.6 Stability of the resource counterfactual across specifications

Table A.8 compares the one-time \$10,000 age-5 resource intervention in the preferred two-type specification with the aligned one-type specification. Unlike the family-transition counterfactual, the resource-only response is essentially invariant to the treatment of permanent family

Table A.3: External time-use check on the parental-investment measures

Sample	Mothers	Participation correlation
2003–2014, children ages 5–13	23,023	0.396
Ages 5–7	10,616	0.426
Ages 8–10	10,673	0.376
Ages 11–13	10,272	0.314
2003–2014, exactly one own child	5,051	0.382
2003–2019, children ages 5–13	29,259	0.465

Notes: The sample contains female American Time Use Survey respondents with an own household child in the indicated age range. Activities are linked through the diary's "who" records to the line number and age of the respondent's own children. The CNLSY-like participation measure indicates any reading with children, museum attendance, or shared social or leisure activity on the diary day. The broader participation measure indicates any activity in a non-overlapping set comprising play, arts and crafts, sports, talking and listening, educational assistance, attendance at children's events, and organization or planning for children. Entries are survey-weighted correlations between indicators for any participation in the two sets of activities. Age groups can overlap when a mother has children in more than one group. The one-child sample makes all child-related diary activities child-specific. The table is intended as an external check on the interpretation of the CNLSY investment indicators and does not compare investment levels across family arrangements.

Table A.4: Reliability of the latent-factor measurement systems

Factor	Age	Reliability	Coverage	Children
Cognitive skill	5	0.986	0.373	1,110
Parental investment	5	0.434	0.711	2,116
Noncognitive skill	5	0.671	0.706	2,101
Cognitive skill	7	0.893	0.732	2,177
Parental investment	7	0.412	0.773	2,300
Noncognitive skill	7	0.673	0.761	2,263
Cognitive skill	9	0.838	0.745	2,215
Parental investment	9	0.316	0.795	2,365
Noncognitive skill	9	0.691	0.782	2,326
Cognitive skill	11	0.808	0.737	2,192
Parental investment	11	0.323	0.792	2,356
Noncognitive skill	11	0.715	0.778	2,315
Cognitive skill	13	0.784	0.683	2,031
Parental investment	13	0.340	0.747	2,222
Noncognitive skill	13	0.723	0.739	2,198

Notes: Reliability averages the information supplied by each child's observed same-domain indicators, conditional on at least one such indicator being observed. Coverage is the proportion of the estimation sample with at least one such indicator. Reliability is one minus the posterior-to-prior variance ratio, using the estimated conditional state variance before the contemporaneous measurement update.

Table A.5: Instrumental-variables comparison of linear and translog skill technologies

Path	Ages	Linear	Translog AME	Difference	Bootstrap SE	95% interval
Panel A. Cognitive-skill technology						
$C_t \to C_{t+2}$	5–7	1.330	1.527	0.197	0.164	[−0.089, 0.569]
$N_t \to C_{t+2}$	5–7	0.057	0.043	-0.014	0.074	[−0.142, 0.147]
$I_t \to C_{t+2}$	5–7	0.040	0.011	-0.029	0.080	[−0.177, 0.163]
$C_t \to C_{t+2}$	7–9	0.886	0.941	0.056	0.055	[−0.035, 0.187]
$N_t \to C_{t+2}$	7–9	-0.003	-0.087	-0.084	0.071	[−0.178, 0.100]
$I_t \to C_{t+2}$	7–9	0.008	0.029	0.021	0.021	[−0.022, 0.061]
$C_t \to C_{t+2}$	9–11	0.760	0.786	0.025	0.047	[−0.089, 0.104]
$N_t \to C_{t+2}$	9–11	0.046	0.040	-0.006	0.080	[−0.129, 0.186]
$I_t \to C_{t+2}$	9–11	0.031	0.006	-0.025	0.036	[−0.079, 0.073]
$C_t \to C_{t+2}$	11–13	0.931	1.024	0.093	0.096	[−0.044, 0.325]
$N_t \to C_{t+2}$	11–13	0.055	0.139	0.085	0.095	[−0.123, 0.263]
$I_t \to C_{t+2}$	11–13	-0.042	-0.064	-0.022	0.049	[−0.113, 0.065]
Panel B. Noncognitive-skill technology						
$C_t \to N_{t+2}$	5–7	-0.191	-0.098	0.093	0.311	[−0.457, 0.866]
$N_t \to N_{t+2}$	5–7	0.455	0.549	0.094	0.142	[−0.297, 0.258]
$I_t \to N_{t+2}$	5–7	0.246	0.234	-0.012	0.136	[−0.306, 0.259]
$C_t \to N_{t+2}$	7–9	0.032	0.043	0.011	0.088	[−0.134, 0.226]
$N_t \to N_{t+2}$	7–9	0.696	0.458	-0.238	0.161	[−0.443, 0.192]
$I_t \to N_{t+2}$	7–9	0.046	0.099	0.052	0.048	[−0.053, 0.150]
$C_t \to N_{t+2}$	9–11	0.044	0.029	-0.014	0.106	[−0.248, 0.234]
$N_t \to N_{t+2}$	9–11	0.666	0.844	0.178	0.162	[−0.239, 0.382]
$I_t \to N_{t+2}$	9–11	-0.007	-0.054	-0.046	0.068	[−0.197, 0.115]
$C_t \to N_{t+2}$	11–13	-0.020	0.031	0.051	0.086	[−0.118, 0.233]
$N_t \to N_{t+2}$	11–13	0.793	1.148	0.355	0.172	[−0.055, 0.609]
$I_t \to N_{t+2}$	11–13	-0.019	-0.065	-0.046	0.081	[−0.238, 0.117]

Notes: The linear and translog technologies are estimated equation by equation using the same sequential instrumental-variables structure, family classifications, income measure, and samples. The translog entries are average marginal effects (AMEs). Difference is translog minus linear. Bootstrap standard errors and percentile intervals use 200 paired mother-cluster resamples; the same resampled mothers enter both specifications in each draw. All 200 draws were accepted for every comparison. The exercise is an auxiliary functional-form check and does not reproduce the latent resource measurement system or permanent-type mixture of the structural model.

Table A.6: Observed and fitted family arrangements and transitions

Panel A. Family-state shares

Age	B		P		L	
	Observed	Fitted	Observed	Fitted	Observed	Fitted
5	0.729	0.697	0.043	0.048	0.227	0.255
7	0.676	0.674	0.075	0.075	0.249	0.250
9	0.625	0.631	0.101	0.101	0.274	0.268
11	0.566	0.572	0.125	0.124	0.309	0.304
13	0.565	0.573	0.128	0.123	0.307	0.305

Panel B. Conditional transition probabilities

Origin	B		P		L	
	Observed	Fitted	Observed	Fitted	Observed	Fitted
Ages 5–7						
B	0.927	0.902	0.012	0.025	0.061	0.073
P	0.147	0.164	0.747	0.744	0.105	0.092
L	0.055	0.080	0.099	0.093	0.845	0.827
Ages 7–9						
B	0.919	0.909	0.018	0.023	0.063	0.067
P	0.123	0.120	0.748	0.779	0.129	0.101
L	0.082	0.061	0.074	0.092	0.844	0.847
Ages 9–11						
B	0.899	0.890	0.029	0.027	0.072	0.083
P	0.121	0.088	0.777	0.799	0.102	0.113
L	0.049	0.043	0.062	0.090	0.889	0.867
Ages 11–13						
B	0.926	0.928	0.019	0.016	0.054	0.056
P	0.145	0.130	0.743	0.747	0.112	0.123
L	0.076	0.064	0.058	0.078	0.866	0.858

Notes: B denotes residence with the mother and biological father, P residence with the mother and a social father or partner, and L residence with a lone mother. Fitted probabilities are one-step-ahead predictions. At each age, type weights incorporate the child's observed family history through the preceding age; Panel B additionally conditions on the observed origin state. Missing earlier family states are integrated out. Panel B uses children whose family arrangement is observed at both adjacent modeled ages.

Table A.7: Additional diagnostics for predictive-moment fit

Domain	Mean MAE	SD MAE	Maximum mean error	Maximum SD error
Adult outcomes	0.041	0.025	0.080	0.044
Cognitive skill	0.023	0.028	0.046	0.117
Financial resources	0.016	0.016	0.022	0.045
Noncognitive skill	0.062	0.018	0.120	0.053
Parental investment	0.040	0.005	0.151	0.019

Measure	Age	Observed mean	Predicted mean
PIAT mathematics	5	-1.421	-1.424
	13	0.997	0.970
PIAT word recognition	5	-1.386	-1.414
	13	1.028	1.046
BPI antisocial behavior	5	0.031	-0.037
	13	-0.017	-0.094
BPI anxiety/depression	5	0.089	-0.031
	13	-0.103	-0.078
Reading/praise	5	0.378	0.318
	13	-0.128	-0.087
Museum visits	5	0.013	0.164
	13	-0.052	-0.082
Centered log family income	5	-0.290	-0.283
	13	-0.161	-0.143
Adult log wage	29	10.119	10.122
Completed schooling	23	13.475	13.555

Notes: Mean absolute error (MAE) is the average absolute difference between the observed and predicted moments within a domain. The upper panel reports this measure separately for means and standard deviations, together with the largest absolute discrepancy in each set of moments. The lower panel reports observed and predicted means for two indicators of each childhood factor at ages 5 and 13, centered log family income at those ages, and both adult outcomes. Reading is the reference investment indicator at age 5 and praise is the corresponding indicator at age 13. Childhood predictions integrate over the fitted family paths and permanent types and condition on the observation pattern for each indicator. Income uses the same centering constant as the estimated measurement equation.

heterogeneity. This comparison helps distinguish the role of persistent selection in family histories from the common developmental response to an externally imposed resource change.

Table A.8: Stability of the one-time $10,000 resource intervention at age 5

Outcome	One type	Two types
Age-13 cognitive skill (SD)	0.0871	0.0870
Age-13 noncognitive skill (SD)	0.1124	0.1107
Completed schooling (years)	0.1533	0.1523
Adult log wages	0.0305	0.0303

Notes: Family arrangements follow their natural fitted paths in both counterfactual worlds. The intervention increases resources once at age 5. Childhood effects use the preferred-model population standard deviations in both columns.